BULLETIN No. 411 JUNE, 1942

The Maine Agricultural Experiment Station

ORONO

Report of Progress for Year Ending
June 30, 1942

UNIVERSITY OF MAINE
THE MAINE AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

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CONTENTS

FRUITS RESEARCH

The fruit industry of Maine represents a combination of enterprises returning an annual cash income of several million dollars. The most important commercial fruit crops in the State are apples and blueberries, each valued at around a million dollars annually. The research with fruits is very largely confined to these two crops although some work is done with strawberries, raspberries, and other small fruits which aside from having some commercial value represent an important food source in the home garden.

APPLES

Apple Breeding. Better hardy, high quality winter varieties of apples are being developed to replace the Ben Davis, Baldwin, etc., which have not proven entirely satisfactory for one reason or another. During the past year, 150 trees of a cross of McIntosh by Golden Delicious were checked for hardiness in laboratory freezing tests by R. M. Bailey, I. M. Burgess, and M. T. Hilborn. One selection from this group has considerable promise from the standpoint of fruit quality and is being propagated for further trial with orchardists.

Another study reported by R. M. Bailey deals with the size

FIG. 1. Seedling apple trees are grown at Highmoor Farm to aid in the production of new varieties.

of the nursery stock when set in the orchard as related to the size of the apple tree in later years. Measurements taken over a period of years show a slight but significant correlation between diameter of the trunk of a 12- to 15-year old tree and its diameter at the time it was set in the orchard as a one or a two year whip. The growth of 400 grade 2 and grade 3 "French Crab" seedlings has been recorded for the past two years. In terms of trunk diameter measurements, the grade 3 seedlings were 69 per cent as large as the grade 2 at the time of setting. After one year's growth the grade 3 seedlings had gained to a size 84 per cent of that of the grade 2, but after two years' growth had moved up to only 86 per cent of the grade 2. These results suggest that it may be worth while for orchardists to avoid the smallest grades of nursery stock.

Orchard Soil Management. J. A. Chucka, R. M. Bailey, and D. S. Fink are checking orchard response to fertilizer and cultural treatments, using 15-year old McIntosh, Northern Spy, and Baldwin trees. The various treatments under trial include (1) inorganic nitrogen alone, (2) nitrogen plus potassium, (3) nitrogen plus phosphorus and potassium, (4) nitrogen applied beneath the tree and a complete fertilizer applied between trees, (5) the application of manure fortified with phosphorus, and (6) the use of hauled-in-mulch in combination with a treatment such as (1), (3), or (4) above. This study has just begun and there are, naturally, no results to report this year.

FIG. 2. Blossoming McIntosh trees on Highmoor Farm.

A study by R. M. Bailey and M. T. Hilborn has to do with the use of cyanamid, nitrate of soda, and manure in orchard fertilization, each of the materials applied separately. Attention is being given to the time of year each of these materials should be applied, with an application of each material being made once annually in August, September, October, or May. This test has been in progress now for three years and no differences have been observed as due to the nitrogen carriers or to the time of their application.

FIG. 3. Winter injury may be a serious problem with some varieties of apples. Injured and uninjured trees at Highmoor Farm.

Winter Hardiness in Apple Trees. It has been found by M. T. Hilborn that much of the loss from winter injury in apple trees can be prevented by the use of hardy interstocks. Virginia Crab and Hibernal as interstock material appear to be satisfactory as trunk-formers in Maine orchards. These two interstocks may not be satisfactory, however, for all scion varieties now being grown commercially in the State. The Baldwin variety has winterkilled severely on Hibernal but is excellent as a scion variety on Vir-

ginia Crab. Cortland has sustained some injury on Virginia Crab but is apparently hardy on Hibernal. This study with interstocks is being continued with numerous materials under test and observation.

FIG. 4. Trees with hardy interstocks, as shown on the left, withstand the winters better than trees with scions directly on the roots.

There is some evidence to indicate that spray materials, used in the control of apple scab, also, may influence hardiness. Laboratory tests were made on material from McIntosh trees under test for scab control since 1928. The trees that had received sulphur dust and mild sulphur spray as a fungicide were the hardiest and those that had received the lime sulphur treatment were the least hardy in these tests.

Field observations disclosed several instances where bark dieback occurred following early winter pruning. The indications are that pruning in November, December, or early January may result in winter injury to the pruning wounds. Pruning in late January, February, or March would seem to be the better practice.

FIG. 5. Demonstrating the eight-nozzle spray rod or gun as used on Highmoor Farm. The saving in labor and material is greater with larger trees. The results are at least as good as with the standard single-nozzle gun.

Apple Scab Control. The various treatments for the control of apple scab on McIntosh were under test by Donald Folsom again in 1941. This season was very dry and scab was easily controlled. The mild sulphur treatment gave about as good control of scab on the leaves as was obtained with lime sulphur and was more effective

on the fruit. The trees treated with mild sulphur produced 23 per cent more fruit in 1941 than did the trees sprayed with lime sulphur. The yield of fruit for the trees treated with mild sulphur had, up to 1940, been about twice as much as for those given lime sulphur. The greatest increase in yield from the mild sulphur treatment was on trees which in years previous to 1940 had received only the lead arsenate coverage. The higher yield of fruit from the trees receiving the mild sulphur was reflected in many more apples of a slightly smaller size. There appeared a tendency for the fruit to have less russeting under the mild sulphur treatment than when lime sulphur was used. The growth of the trees, as measured by trunk girth, was slightly greater under the mild sulphur treatment than for any other. Pertinent data on this study are given in Tables 1, 2, 3, and 4 in the Appendix.

Apple Insects. Among the most important apple insects in Maine are the Apple Fruit Fly (*Rhagoletis pomonella* Walsh), the Gypsy Moth (*Porthetria dispar* L.), and the Round-Headed Appletree Borer (*Saperda candida* Fab.). Studies on these insects and on methods for their control have been continued by Frank H. Lathrop.

The Gypsy Moth. Many of the gypsy moth eggs failed to survive the winter of 1940-41 in the area extending through Augusta and Buckfield. Consequently, the infestation in this area was much lighter in 1941 than in previous years. The carry-over of gypsy moth in this area during the winter of 1941-42 was, therefore, very light in comparison with the severe infestations during the years 1937 to 1940 inclusive. Farther south in the State, however, the egg mortality in the winter of 1940-41 was not so great and in many of the important apple growing areas of York and Cumberland Counties, the gypsy moth continued to be a destructive pest in the apple orchards.

The best control so far developed for this insect is to cover the apple trees just before the blossoms open with a spray containing 3 or 4 pounds of lead arsenate per 100 gallons, and to follow this with another application in the calyx stage. In case of a severe infestation, lead arsenate is important in the spray applied 7 to 10 days after the calyx. Where dust was used, 15 per cent lead arsenate and 85 per cent dusting sulphur did not give complete control. In the case of severe infestations it might be advisable to increase

the percentage of lead arsenate in the dust. A 75-25 mixture is being tested.

FIG. 6. Young apples (above) showing fresh scars made by gypsy moth larvae, and mature fruit (below) showing the type of blemish resulting from gypsy moth attacks. Lead arsenate applied in the early sprays will prevent such injury.

The Apple Fruit Fly. In line with the early spring of 1941, the emergence of apple fruit flies was the earliest of any season for the past 10 or 12 years. Emergence throughout the season was 10 or 11 days ahead of the average for previous years of record. The first flies emerged at Highmoor Farm on June 16; on July 4, 25 per cent had emerged; July 9, 50 per cent; July 15, 75 per cent; July 20, 90 per cent; and on August 1, 99 per cent of the flies had emerged.

Counts of infestation in neglected apple trees in the vicinity of Monmouth showed that the flies began to lay eggs in the apples about July 1, which was approximately 10 or 15 days earlier than in 1940. It appeared that the warm, dry summer of 1941 was not so favorable for the flies, however, and apparently fewer eggs were laid than in 1940.

Experiments in the control of the apple fruit fly by means of arsenical dusts showed that the residues remaining on the foliage from arsenical dust applied before the recommended fruit-fly applications were important in the control of this pest. Apparently the application of an excessie quantity of dust does not increase the control proportionately. Too little dust is not effective, however, even though the number of applications is increased. Results showed that in the case of a severe infestation, ¼ pound of 90-10 (sulphur-calcium arsenate) dust per tree per application was insufficient for complete control on trees of 14.5 feet average height, and 21.4 feet average spread. A minimum of ½ pound is recommended for trees of this size.

FIG. 7. *Left* —Unsightly blotches of residue from the application of the spray recommended for fruit fly control.
Right—The deposit was smoothed out on these apples by adding 3 gallons of skim milk per 100 gallons of spray.

In connection with the use of spray or dust for the control of the apple fruit fly and the gypsy moth, samples of foliage were analyzed by E. R. Tobey and B. E. Plummer, Jr. to ascertain the amounts of arsenical deposit per unit area of leaf surface. The amount of arsenic deposited by liquid spray was greater per unit area of leaf surface than it was when dust was used.

The Round-Headed Apple-Tree Borer. In attempting to control the round-headed apple-tree borer, it is important to know when the adult insects are active in the orchard. Experimental data accumulated since 1938 on the time of emergence of the adult borers show that they usually begin emerging from the tree trunks during the second week after petal-fall. A summary of the records is shown in Figure 8. The emergence reaches a peak during the third and fourth weeks after petal-fall, when the borers appear in greatest numbers. Fairly heavy emergence may be expected to continue during the fifth and sixth weeks after petal-fall, followed by emergence of relatively small numbers of borers throughout the rest of the season. The earliest calendar date on which emergence

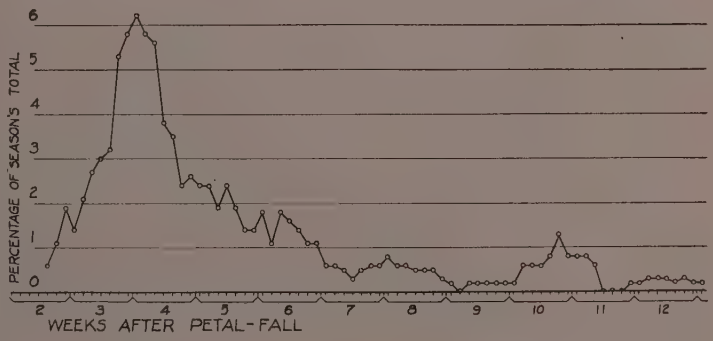

FIG. 8. Emergence of adult round-headed apple-tree borers from trees at Monmouth, Maine, during the four years, 1938 to 1941, inclusive. Notice that emergence started during the second week after petal-fall; reached a peak during the third and fourth weeks; and continued in reduced numbers throughout the rest of the summer. The average date of McIntosh petal-fall at Highmoor Farm, Monmouth, during the past 12 years, was May 30.* (The records include a total of 125 adults during the 4 years, and the curve was smoothed by use of a 5-day moving average.)

* Records of dates of petal-fall by Donald Folsom, Plant Pathologist, Maine Experiment Station.

was recorded was in 1941, when 4 adults appeared in the experimental cages on June 6. The season was exceptionally early in the spring of 1941, and June 6 was the 15th day after petal-fall. The earliest emergence with respect to petal-fall occurred on the 12th day after petal-fall in 1939, a year in which the spring season was late, the 12th day after petal-fall occurring on June 17. The latest calendar date record of last emergence in the season was August 28 (1940) which, being the 85th day, was also the latest with respect to petal-fall. The observations in Maine, as well as the careful studies by Hess* in New York, show that on the average the adults may live several weeks. It will be seen, therefore, that the adults are active and laying eggs from about the third week after petal-fall until the end of the summer.

The results of this study emphasize that "worming" the trees by mechanical means or by means of chemicals injected into the borer tunnels can be performed most effectively in the spring before the second week after petal-fall, and again in the fall beginning about September 15.

Russeting of Golden Delicious Apples. The russeting of the Golden Delicious apple frequently is a serious defect from the market standpoint. F. B. Chandler and I. C. Mason have studied this problem with a view to ascertaining the cause of russeting and, if possible, to develop a means for preventing it. No single factor was found that could be assigned definitely as the cause of russeting. The conclusions are that russeting of the Golden Delicious may be caused by one or more of the following: (1) a bud mutation whereby one or more branches on the tree would be different from the rest of the tree, (2) one or more of the factors interstock, rootstock, and soil, and (3) a range of weekly precipitation with the maximum not in excess of two inches during the period of July 3 to July 28.

SMALL FRUITS

The work with small fruits, as indicated above, is confined very largely to blueberries. The studies include both the high-bush and the low-bush varieties but the emphasis has been on the latter in view of its greater commercial importance.

* Hess, A. D., The Biology and Control of the Round-Headed Apple-Tree Borer, *Saperda candida* Fabricius, New York Exp. Sta. Bul. 688, 1940.

Breeding Blueberries. It has been found that the low-bush blueberry has two general types so far as the growth of plant is concerned. One type has plants about 6 to 10 inches tall and is very common but produces a small first crop of berries and a very

FIG. 9. Blueberry rake. Grass would seriously hamper this operation.

small second crop. The second type has plants about 8 to 14 inches tall and is found only in protected locations but produces a large first crop of berries and also a large second crop. Crosses have been made by F. B. Chandler and I. C. Mason between plants of the two types with a view to developing a variety that will produce two or more large crops of berries in the years between burns.

Blueberry Field Management. Grass is frequently a problem in blueberry fields but can be controlled by the pasturing of geese in the field, according to F. B. Chandler and I. C. Mason. Where the grass is abundant, two geese per acre will give good control and where the grass is not so abundant two can range 10 to 15 acres. The geese may be pastured on the land all summer in the year the land is burned, and in crop years up to July 1, or until the berries begin to ripen.

A study on mulch versus clean culture in the growing of highbush blueberries disclosed that plants grown on sandy or sandy loam soils made better growth under clean culture than when mulched. Plants on a clay loam soil, however, made better growth under mulch than when clean culture was practiced.

Blueberry Insects. There are two quite important insects affecting blueberries, the Blueberry Fruit Fly (*Rhagoletis pomonella* Walsh) and the Blueberry Thrips (*Frankliniella vaccinii* Morgan). Studies by Frank H. Lathrop have been continued with these two insects to improve the methods of control.

Blueberry Fruit Fly. A comparison was made in 1941 of calcium arsenate dust and several non-arsenical dusts. An application was made on July 11, 20, and 29 using a power driven orchard duster drawn over the blueberry land in lanes approximately 100 feet wide. Each dust was applied at the rate of 6 pounds per acre at each application. The fruit from any of the treated areas had fewer fruit fly larvae than did the fruit from untreated areas. A 2 per cent rotenone dust was just as effective in the control of this pest as was calcium arsenate. The rotenone in this particular formula was in the form of finely ground derris root and the bulk of the dust was composed of equal parts of diatomaceous earth and talc. Terpene ethers (4 per cent) and sodium lauryl sulphate (1 per cent) were added as conditioning agents. The blueberry plants on plots treated with any of the rotenone dusts suffered decidedly less injury than did the plants on plots treated with calcium arsenate. Pertinent data on this experiment are given in Table 5 in the Appendix.

Blueberry Thrips. Examinations of the experimental spray plots in the spring of 1941, showed that one application of kerosene emulsion made to the soil, during the period when the thrips were dormant, gave excellent control of this insect. The emulsion contained 1 pint of kerosene per gallon, and was applied to the soil

at the rate of 1 gallon of emulsion per square yard of soil surface. The kerosene emulsion was equally effective when applied either in the late fall or in the early spring. Where an application was made in the fall, followed by a second application in the spring, the blueberry plants were severely injured. Where a single application was made, however, either in the fall or in the spring, no injury to the plants was apparent.

FIG. 10. Typical clusters of tightly curled leaves mark the plants infested by blueberry thrips. The thrips are minute insects, almost microscopically small, that during the growing period live, feed, and multiply within the protection of the curled leaves. They can be controlled with the application of kerosene emulsion to the soil.

Blueberry Fruit in Storage. Fresh blueberries are usually very much in demand and a considerable portion of the crop is marketed as fresh fruit. It was found by F. B. Chandler that blueberries may be kept commercially for anywhere from 2 to 4 weeks without any appreciable loss in quality. The berries in this test were held at a temperature of 41° F. in an atmosphere with

an oxygen content of 5 per cent and a carbon dioxide content of 10 to 15 per cent. The commercial storage of blueberries may benefit the growers who sell berries as fresh fruit since it will enable them to store along toward the end of the fresh fruit season when the price is usually low, and to sell later when the price advances. Blueberries may be kept in the home refrigerator for several months. The berries should be put into clean jars which are then sealed and placed in the refrigerator. The berries use up the oxygen in the sealed jar and produce carbon dioxide very nearly in the proportion desired as indicated above for commercial storage.

Blueberry Juice. The juice from Maine-grown blueberries when properly extracted, is equal, in flavor and quality, to juice from blueberries in any other area. The juice contains 9 to 10 per cent reducing sugars and less than one per cent of non-reducing sugars and amino acids. The sediment in well prepared juice is less than 2 per cent by volume. The yield of juice from cooked berries is 10 to 20 per cent less than from uncooked berries treated with pectinol. The fresh berries should be ground or mashed. Then one-tenth of one per cent of pectinol M by weight should be added and mixed with the ground fruit and the mixture allowed to stand for 8 to 24 hours before the juice is extracted. Pectinol M is an enzyme that destroys the pectin in the fruit and releases the juice held by the pectin. Pectinol M is not found on the market locally but may be obtained from Röhm and Haas Company, Inc., Philadelphia, Pennsylvania.

NOTE: Additional information on any of the research of the Experiment Station may be obtained by writing directly to the individuals doing the work. The following bulletins report the results of some of the studies. These may be obtained free upon request.

A Histological Evaluation of Low Temperature Injury to Apple Trees. Me. Agr. Exp. Sta. Bul. No. 388.

Apple Spraying and Dusting Experiments 1928 to 1932 in Relation to Scab, Yield, and Tree Growth. Me. Agr. Exp. Sta. Bul. No. 368.

An Economic Survey of The Apple Industry in Maine. Me. Agr. Exp. Sta. Bul. No. 339.

An Economic Study of 93 Apple Farms in Oxford County, Maine. 1924-1927. Me. Agr. Exp. Sta. Bul. No. 347.

An Economic Study of 239 Blueberry Farms in Washington and Hancock Counties, Maine. Me. Agr. Exp. Sta. Bul. No. 351.

APPENDIX

TABLE 1

Treatment for Control of Scab on Apples. Highmoor Farm, 1941

Fungicide 1940[1]	Fungicide 1941	Leaf scab	Fruit scab	Fruits russeted	Fruits clean
		Per cent	Per cent	Per cent	Per cent
Lime sulphur	Lime sulphur	0.2	0.3	0.5	99.2
" "	Mild "	0.7	0.2	0.3	99.5
Mild "	Lime "	0.3	0.3	0.6	99.1
" "	Mild "	0.8	0.0	0.3	99.7
Lead arsenate	Lime "	0.9	0.0	0.2	99.8
" "	Mild "	0.3	0.0	0.2	99.8
Lime sulphur, mild sulphur, or lead arsenate	Lime "	0.4	0.2	0.5	99.3
Ditto	Mild "	0.7	0.05	0.3	99.7

[1] Up to 1940 inclusive, each tree had received the same fungicidal treatment from season to season for ten or more years—either dry lime sulphur spray, mild sulphur (dust or spray), or merely the minimum requirement of lead arsenate (applied against tent caterpillar and gypsy moth, but acting also as a mild fungicide against scab).

TABLE 2

Type of Fungicide in Relation to Apple Tree Growth and Yield of Fruit. Highmoor Farm, 1941

Fungicide 1940[1]	Fungicide 1941	No. of trees	Yield per tree				Average trunk girth 1940		Average trunk growth 1941		Fruit size 1941[2]	Fruit color 1941[5]
			To 1940 inclusive		1941							
			Lbs.	Relative	Lbs.	Relative	Cm.	Relative	Cm.	Relative		
L.s.	L.s.[3]	72	174	104	64	100	43.0	104	4.2	120	147	.70
L.s.	M.s.[4]	59	167	100	67	105	42.9	104	4.5	129	155	.75
M.s.	L.s.	65	304	182	87	136	42.7	103	3.7	106	156	.77
M.s.	M.s.	65	312	187	98	153	42.9	104	4.1	117	160	.75
L.s.	L.s.	37	217	130	93	145	41.4	100	3.5	100	148	.73
L.s.	M.s.	37	214	128	140	219	43.8	106	3.5	100	155	.69
All	L.s.	174	232		78		42.6		3.9		150	
All	M.s.	161	236		96		43.1		4.1		157	

[1] Up to 1940 inclusive, each tree had received the same fungicidal treatment from one season to another for at least ten years—either dry lime sulphur spray, mild sulphur (dust or spray), or merely the minimum requirement of lead arsenate (applied against tent caterpillar and gypsy moth, but acting also as a mild fungicide against scab).

[2] Number per bushel.

[3] Dry lime sulphur spray 4-50 applied seven times.

[4] Mild sulphur spray, mostly micronized 5-50 but partly flotation dry wettable 5-50, applied seven times, except for a mid-blossom application in addition on the trees receiving lead arsenate 1940.

[5] Average area estimated to be red.

TABLE 3

The Effect of Kind of Apple Fungicide on Comparative Basis. Highmoor Farm, 1941

Item	Fungicide 1940[1]	Comparative amount of item 1941[2]	
		L.s. 1941	M.s. 1941
Lbs. fruit per tree to 1940 inclusive	L.s.	100	96
	M.s.	100	103
	L.a.	100	99
	All	100	102
Lbs. fruit per tree 1941	L.s.	100	105
	M.s.	100	113
	L.a.	100	151
	All	100	123
Average trunk girth 1940	L.s.	100	100
	M.s.	100	100
	L.a.	100	106
	All	100	101
Average trunk girth 1941	L.s.	100	107
	M.s.	100	111
	L.a.	100	100
	All	100	105
Fruit size 1941[3]	L.s.	100	105
	M.s.	100	103
	L.a.	100	105
	All	100	105

[1] Up to 1940 inclusive, each tree had received the same ungicidal treatment season after season for ten years or longer—either dry lime sulphur spray, mild sulphur (dust or spray), or only the minimum requirement of lead arsenate (applied against tent caterpillar and gypsy moth, but acting also as a mild fungicide against scab).

[2] Based upon figures in Table 2.

[3] Number per bushel. Five per cent more per bushel means an average size 5 per cent smaller.

TABLE 4

Fungicide in Relation to Apple Blossom Abundance, and Fruit Set and Drop. Highmoor Farm, 1941

Fungicide 1940[1]	Fungicide 1941	Blossom abundance[4]	Blossoms set[5]		Drop of June 1 fruits[5]		
			June 1	June 29	By June 15	By June 29	By August 8
			Per cent	Per cent	Per cent	Per cent	Per cent
L.s.	L.s.[2]	2.35	32	8	42	75	75
L.s.	M.s.[3]	2.32	—	—	—	—	—
M.s.	L.s.	3.09	—	—	—	—	—
M.s.	M.s.	3.14	24	7	42	72	73
L.a.	L.s.	3.35	—	—	—	—	—
L.a.	M.s.	3.78	—	—	—	—	—
All	L.s.	2.84	—	—	—	—	—
All	M.s.	2.99	—	—	—	—	—

[1] Up to 1940 inclusive, each tree had received the same fungicidal treatment for 10 or more years—either dry lime sulphur spray, mild sulphur dust or spray, or lead arsenate just enough to control tent caterpillar and gypsy moth (and slightly reducing scab).

[2] Dry lime sulphur spray 4-50 applied five times before June 29 and twice later.

[3] Mild sulphur spray, mostly micronized 5-50 but partly flotation dry wettable 5-50, applied on same dates as the lime sulphur.

[4] Mean for all trees. Estimated in six grades from 0 (none) to 5 (most).

[5] On ten branches per treatment.

TABLE 5

Results of Dust Applications for the Control of Blueberry Fruit Fly (Rhagoletis pomonella) in 1941

Dust treatment applied	Average number of fruit fly larvae per 20-ounce sample of berries
[1]Rotenone 1 per cent 3 applications	2.3
[1]Rotenone 2 per cent 3 applications	1.0
[2]"Lethane-Rotenone" 3 applications	2.0
Calcium arsenate 3 applications	1.3
Check—no treatment	7.9

[1] The rotenone was in the form of finely ground derris root. The bulk of the dust was composed of equal parts of diatomaceous earth and talc. Terpene ethers 4 per cent, and sodium lauryl sulphate 1 per cent, were added to the dust, as conditioning agents.

[2] Lethane-Rotenone dust was manufactured by Röhm and Haas Company, Philadelphia, and contained 1.8 per cent "Lethane 384," plus 0.7 per cent rotenone, with pyrophyllite as a carrier.

CANNING AND GARDEN CROPS

The canning and garden crops on which research is done include the more important commercial crops such as corn, peas, and snap beans, and the most commonly grown garden crops such as tomatoes, cabbage, lettuce, squash, etc.

SWEET CORN

Good yields of high quality sweet corn are of primary importance in the production of sweet corn for manufacture. Such yields can be maintained with the use of hybrid varieties and with proper fertilization practices. These two factors have been given the major attention in the research with sweet corn.

FIG. 1. Well isolated fields aid in the production of hybridized sweet corn seed. Seed is saved only from the detasseled variety planted between the male parent rows, usually 3 seed rows to one pollen row.

Sweet Corn Breeding. Considerable attention is being given by R. M. Bailey and R. W. Buck to the development of breeding stock for the production of hybrids suitable for the Maine canning industry. About 30 promising hybrids were in an extensive trial at Fryeburg and at Highmoor Farm. Several of these, including some three-way crosses, appear good from the standpoint of yield,

quality, and plant and ear characters. The three-way cross offers possibilities for economical seed production. The method is simply to cross two inbred lines and use the hybrid the following year as the female parent and a third inbred line as the male parent. The seed crop for commercial planting, therefore, is harvested from a first-year hybrid and the yield is good enough to make the operation economically practicable. The commercial phases of this program have received financial assistance from the Maine Canners' Association through a cooperative arrangement.

Sweet Corn Fertilization. Different amounts and placements of fertilizer are being tested by J. A. Chucka and J. L. Harrington. Due apparently to less rainfall during the 1941 season than usual the yields for the various treatments were not greatly different. The corn plant seems unable to use effectively the plant food available to it unless moisture is adequate. A per acre application of 500 pounds of an 8-24-8 fertilizer in the row at planting time followed with a side dressing of 150 pounds of nitrate of soda when the corn was knee-high, produced as good a yield of sweet corn in 1941 as any treatment used.

BEANS

Beans are grown in Maine both as snap beans and as dry. The development of disease-resistant varieties is of considerable importance in combating anthracnose and halo blight which are two of the most troublesome diseases in this State.

Bean Breeding. Snap Beans. White seeds and round pods are desirable qualities in both green and wax varieties. Several selections made by I. M. Burgess and R. M. Bailey from the crosses Hercules x Conserva and Hercules x Brittle Wax appear to have promise both for canning and for frozen pack. These strains are being continued for further tests.

Dry Beans. The Old Fashioned Yellow Eye variety has been a very popular one. It is hoped that its general qualities may be retained in a new variety possessing resistance to some of the more troublesome diseases.

Segregates with desirable seed and plant type obtained from crosses, in which the Old Fashioned Yellow Eye variety was one parent, were subjected to field inoculations with anthracnose (rust).

Lines free from disease and selections from those lines partly free have been saved for further testing in 1942.

FIG. 2. Considerable attention is given to beans, both green and dry, at Highmoor Farm.

In 1941, apparently blight resistant plants were found in a blight-ruined bean field. Both halo blight and common bacterial blight were found by Donald Folsom to be present on affected plants. Since high resistance to both of these diseases is rare, seed from these apparently resistant plants was saved. The seed stock will be multiplied in order to provide enough plants for tests with artificial inoculation to ascertain the degree of resistance of this discovery. Should the resistance to blight be as it appears to be this selection will be used as breeding material to transfer the resistance to beans of more desirable type.

Bean Variety Trials. Among the newer snap beans the Tenderpod variety was excellent in quality but was somewhat low in yield. The Streamliner and the World's Fair varieties produced high yields but were of inferior quality.

Bean Insects. The most serious insect pest in the bean fields of Maine at present is the Mexican bean beetle. Any other insects affecting this crop are of comparatively minor importance.

Mexican Bean Beetle. Mexican bean beetles of the overwin-

tering generation were found by J. H. Hawkins on beans early in June during the 1941 season. Feeding by these adults caused considerable injury to the young bean plants. Eggs were laid by the beetles immediately and continually for a month or more and larvae fed on beans all through the season until freezing weather, except where the plants had been protected with insecticides.

FIG. 3. Bean variety and strain tests at Highmoor Farm.

The early application of an insecticide served to prevent feeding by the adult beetles. Such young larvae as hatched from the eggs on treated plots were killed before they were large enough to cause extensive injury to the beans. It is recommended that insecticides be applied from June 10 to June 20, depending upon when the beetles first appear. Effective insecticides carefully applied, during the summer and fall months, will diminish the number of beetles which seek winter hibernating quarters under what may be expected when insecticides are not applied.

Data on hand indicate the value of properly mixing dusts and sprays and applying them carefully to the bean plants. This is especially true when dusts are used, since any kind of dust may not be effective if it is poorly mixed. Bean foliage is especially susceptible to burning by calcium arsenate when it is an ingredient

of poorly mixed dusts. An even spread of materials over the bean plants is desirable to protect all portions of the plants. Dusts and sprays are most effective when applied so that the under portions of the bean leaves, where the larvae of the Mexican bean beetle feed, are well covered. In general dusts applied when the plants were wet with dew were more effective than were dusts applied when the plants were not moist. Dusts applied at dusk, however, just before dew falls have proven effective and by applying the treatment when the plants are dry the operation will not materially aid the spread of disease. Sprays containing water can be effectively applied at any time of day when the wind is not too high. If rain should follow immediately after a spray or dust treatment, another application should be made in order to have the beans continually protected.

Beans treated with various insecticides for the control of the Mexican bean beetle were observed throughout the season for the effect of the insecticides on the beans and for the effectiveness of various materials in control of this insect. The beans were harvested and weighed and the yields from the various plots were compared. Some treated plots produced slightly higher yields than did the untreated check plots. The following formulas have promise: (1) calcium arsenate 1 part, monohydrated copper sulphate 7 parts, and magnesium lime 28 parts; (2) a mixture containing derris root to make 1% rotenone and using magnesia talc as the base; and (3) a mixture containing 2½ pounds of flour, 2½ pounds of insoluble copper, and 2½ pounds of derris (4.8% rotenone) in 50 gallons of water. Higher yields of beans were obtained from plots treated with mixtures containing magnesium lime rather than calcium lime where lime was one of the ingredients used. Apparently there is much less injury to the bean foliage if lime containing about 32 per cent of magnesium oxide is used when calcium arsenate is employed as an insecticide. Pertinent data on insecticides tested and the plot yields are given in Tables 1 and 2 in the Appendix. The data that were obtained indicate that the thorough washing and processing for canning that is practiced by the canners of Maine is effective in removing harmful arsenicals from beans which have been dusted with insecticides used in the control of the Mexican bean beetle. However, until more data are available, it is recommended that rotenone be used after the pods are formed on the plants being grown for dry beans, and that sub-

stances less poisonous than the arsenicals be used on snap beans at all times. The canning companies have special rules regarding the use of arsenicals on canning products and it is advisable to consult their representatives before applying insecticides. Arsenic can be used on dry beans safely before the pods are formed unless the bean refuse is to be fed to livestock. Data on arsenical residues are given in Table 3 in the Appendix.

Bean Weevil. Weevils frequently cause serious damage to beans held in storage. Preliminary studies by F. H. Lathrop suggest that storage temperatures have a very definite bearing on the development of this insect. In beans held in storage at a temperature varying from 70° to 80° F. the weevils increased from 10 in each container under observation to 77 during a period of approximately six weeks. In beans held in storage at a temperature varying between 35° and 50° F. the weevils did not increase in number. The weevils in the cold room deposited small numbers of malformed eggs which failed to hatch.

PEAS

One of the problems confronting the growers of peas is the control of aphids which in some years cause considerable damage to the crop. The evaluation of methods for control of this insect comprises the major part of the attention given to this crop in the Station research program.

Pea Aphid Investigations. The aphid infestation varies considerably with weather conditions. Apparently the 1941 season was not particularly favorable to the development of excessive numbers, and consequently the aphid injury to canning peas was not serious. It has been found by J. H. Hawkins that a scarcity of aphids in any season may be accompanied by a scarcity also of their parasites and predators. The so-called fungus disease of aphids continues to be an important natural factor in the control of pea aphids. A close watch of the crop will enable the growers to be forewarned of natural controls in time to apply insecticides if conditions appear to warrant their use. Evidence from research indicates that satisfactory control of this insect depends not alone on the use of an effective insecticide but also involves the proper timing and careful application of the materials used.

Machinery used in the application of insecticides, previous to the time the pods are formed and filled, causes a minimum of injury and vines which are trodden down soon recover. Also, an early application of insecticides will kill the aphids when many are small and before reproduction has progressed to the extent where the aphid population is capable of causing serious destruction to the pea crop. Once the crop has progressed to the stage where peas are developing in the pods it is probably too late for the use of an insecticide to be economically practicable. At this late date the damage to the crop by the machinery used in applying the insecticides together with the costs for labor and materials probably will cost the grower more than he could expect to save on his crop by killing the aphids.

Observations made on dusting operations indicate that excessive injury may be caused by the slipping of the wheels of the truck used in carrying the dusting machinery. Wheel slipping occurred most often in fields in which the pea vines were wet and the soil was sloping. There is some evidence that tire chains on trucks used in the fields where there is danger of slipping, prevents to some extent the tearing up of the vines and consequently their use may avoid excessive injury to the crop. Treatments made when the pea vines and soil were moderately dry were satisfactory from the standpoint of the small amount of injury caused to the crop by the machinery used.

Conditions favorable to the effectiveness of the insecticide are not necessarily the same as from the standpoint of injury caused to the vines by the machinery. This is especially true where the insecticide is applied in the form of a dust, as a certain amount of moisture apparently increases the effectiveness of an insecticide. On the other hand, rainfall immediately following the application of pea aphid dust washes the dust off and decreases its effectiveness. Dusts are most effective when timed so that the application is made while the peas are in blossom. If the aphids are abundant, excessive injury to the peas is in prospect but an insecticide at this time gets them before they can do much damage. Timing should coincide also with the best conditions consistent with the propagation of predaceous and parasitic insects and diseases. If natural agencies are functioning properly they will control the pea aphids without the application of artificial means. Since diseases and parasites do not usually become abundant until the pea crop is well advanced, the

late applications of insecticides should be avoided whenever possible. Timing of the application to coincide with calm, warm weather when rain is not likely to occur immediately, has resulted in the most satisfactory control of pea aphids.

A rotenone dust, made up according to one of the formulas indicated below, was effective in the control of aphids on peas.

Formula No. 1: Ground derris root to insure rotenone content of 1%; a wetting or spreading agent (such as peanut or soya oil) 2%; and an inert carrier. A combination of Celite and talc makes a good carrier.

Formula No. 2: Ground derris root to insure rotenone content of 1%; a wetting or spreading agent 1%; terpene ether 4%; and an inert carrier.

VEGETABLE VARIETY TRIALS

Variety plots of various vegetable crops were grown by I. M. Burgess at Highmoor Farm, Monmouth, and on privately owned farms in the Cape Elizabeth section and in the towns of Kennebunk and Kennebunkport. These tests are mostly of crops which are grown as market garden produce and for home consumption.

Lettuce. In the Cape Elizabeth section, lettuce in the 1941 season received a severe test because of the dry and unusually warm weather. Of the commercial varieties, Imperial 44 showed the greatest ability to develop good heads. Imperial 850 was somewhat better in this respect than Imperial 847 but both of these varieties developed a considerable percentage of very large soft heads. Imperial 850 was affected somewhat less by tipburn than either 44 or 847. Stocks to be known as Imperial 456 and as Great Lakes were outstanding in performance, the first mentioned having 100 per cent firm and hard heads and no tipburn.

Tomatoes. In the variety plots, Stokesdale was outstanding in general quality for a main crop tomato. Its firm fruit was especially desirable for market purposes. Victor and Bounty were not the earliest but both produced heavy early crops. Bounty was superior to Victor both at Kennebunk and Monmouth. Early Danmark was noteworthy for its early yield of smooth, nearly crack-free fruit.

Selections No. 85 and F.N.C. have been distributed throughout the State for trial in home gardens. These two selections are very early and have possibilities as part of the planting for home garden use.

F_1 tomato hybrids are under test and these have definite possibilities. Among numerous crosses tried, Pritchard by Early Danmark was outstanding in the production of early fruit.

Cabbage. Baby Head and Premier early cabbages of the Golden Acre type were the earliest maturing varieties and formed high percentages of hard heads. Round Dutch produced an exceptionally high percentage of solid but somewhat small heads and has possibilities for a midseason variety.

FIG. 4. The garden at Highmoor Farm includes tests of many different crops.

Peppers. Windsor "A" pepper has been a dependable early variety. Harris Wonder is not as early but is of more desirable type for market.

Eggplant. New Hampshire Hybrid eggplant is not as early as Blackie but has more attractive fruit. The small fruited kinds, Kissin, Black Bountiful, and Black King, have been earlier and more dependable than the larger fruited kinds.

Pumpkin and Squash. Cheyenne pumpkin was not as productive as New England Pie (Small Sugar) and not enough earlier to give it preference. Yankee Hybrid summer squash was quite early and was more productive than its parents. Early Prolific was, however, considered more attractive.

Melons. Honey Cream, Tough Sweets, and Dakota Sweet were still considered the best in quality of the small early watermelons grown. At Kennebunkport, Honey Cream was inferior in quality while Dakota Sweet seemed the preferable kind.

NOTE: Further information on any of the work reported in this bulletin may be had by writing directly to the staff doing the work, or letters of inquiry may be addressed merely "The Maine Agricultural Experiment Station, Orono, Maine."

APPENDIX

TABLE 1

Showing the Effect of Insecticides on Bean Yields

Materials used	Differences in yield of treated plots from yields of untreated check plots
Dusts	
1. Calcium arsenate, 1 part Magnesium lime, 7 parts	No significant difference
2. Calcium arsenate, 1 part in 7 parts of a dust made of monohydrated copper sulfate, 1 part, and magnesium lime, 4 parts	Slight increase
3. Derris root to make 1% rotenone Remainder magnesia talc	Slight increase
Sprays	
4. 1½ lb. calcium arsenate, 5 lb. copper sulfate, 5 lb. magnesium lime, 5 gal. water	No significant difference
5. 1½ lb. calcium arsenate, 5 lb. insoluble copper, 5 lb. flour, 50 gal. water	No significant difference
6. 2½ lb. derris (4.8% rotenone), 2½ lb. flour, 2½ lb. insoluble copper, 50 gal. water	Slight increase

TABLE 2

Increase in the Yield of Dry Beans in Plots Treated with Magnesium Lime Combinations

Materials used		Yield of dry beans in pounds
Calcium arsenate 1 part Magnesium lime, 7 parts		51.08
Calcium arsenate 1 part Lime containing no magnesium, 7 parts		25.87
	Increase	25.21
Calcium arsenate 1 part 20-80 copper lime magnesium lime dust, 7 parts		51.23
Calcium arsenate 1 part 20-80 copper lime dust, 7 parts		42.04
	Increase	9.19

TABLE 3

*Arsenical Residue on String Beans Before and After Canning, 1941**

Description of sample			Grains of As_2O_3 per pound of beans
1–D Series Calcium arsenate 5 lb. Magnesium lime 45 lb.	1 treatment	fresh beans	.0056
		canned beans	.0017
	2 treatments	fresh beans	.0147
		canned beans	.0027
	3 treatments	fresh beans	.2225
		canned beans	.0067
4–D Series Calcium arsenate 1 part to 7 parts 20-80 copper-lime dust	1 treatment	fresh beans	.0045
		canned beans	.007
	2 treatments	fresh beans	.008
		canned beans	.002
	3 treatments	fresh beans	.0206
		canned beans	.0046
7–D Series Calcium arsenate 1 part to 7 parts magnesium talc	1 treatment	fresh beans	.007
		canned beans	.0017

* Chemical analysis of the beans for arsenical residues by B. E. Plummer, Jr., Department of Chemistry, Maine Agricultural Experiment Station.

POTATOES

The potato industry is the most important agricultural enterprise in the State from the standpoint of cash income. The problems of this industry, therefore, naturally receive considerable attention in the research program of the Station. Furthermore, the potato growers themselves, becoming concerned with the disease problems threatening the success of their industry, have made available from the Potato Tax revenue, a substantial fund annually for research on methods for the control of the most serious potato diseases. The support for studies with potatoes, for the fiscal year ending June 30, 1942, was about equally divided between Potato Tax funds and those received from regular Federal and State appropriations. In addition, funds for the construction of a greenhouse at Aroostook Farm were made available from a carry-over of Potato Tax income from the 1940 potato crop. This new greenhouse was completed about January 1, 1942, and is a decided asset in the research program on potato diseases. There are, of course, problems in the production and marketing of potatoes aside from those of disease and these are receiving due attention as may be seen from this report.

POTATO DISEASES

The attention of everyone connected with the potato industry has been focused more recently upon leafroll (net necrosis), stem-end browning, bacterial ring rot, and purple top. Concentration of effort has been on these important disease problems but other diseases such as late blight, rhizoctonia, and mild mosaic have not been neglected.

Bacterial Ring Rot. There are three methods of approach for the control of ring rot in potatoes. The first and most promising method, on the long-time basis, is the development of a variety, or varieties, resistant or immune to the disease. The second method is applicable to present commercial varieties but only to those seed stocks which are known to be absolutely free of ring rot. It is a method of rigid sanitation. A third method is available to those growers who have seed stocks in which there is known to be ring rot infection. The method involves the purchase of a small quantity of new seed stock known to be free from infection with this disease,

FIG. 1. Green Mountain potato plant on the right showing typical bacterial ring rot symptoms in the field. Note healthy stalk on the left.

and the use of seed plot methods combined with rigid sanitation while increasing this stock for general farm planting. The evidence from research amply supports the statements just made as may be seen from the following discussion.

RESISTANT VARIETIES. A few named varieties of potatoes and several unnamed seedlings[1] have been found by Reiner Bonde and Stanislas F. Snieszko to be resistant or immune to ring rot infection. None of these in themselves offer much from the standpoint of a table stock potato. They do, however, provide parent material for hybridization with other varieties. They provide, also, assurance that in due time a good table stock potato can be developed which will be resistant or immune to ring rot. The production of new varieties requires several years, since all promising seedlings must be subjected to severe tests for resistance, and these tests are

[1] The potato breeding program is a cooperative study with the Bureau of Plant Industry of the U. S. Department of Agriculture. The headquarters of the Bureau staff in Maine is at Aroostook Farm, Presque Isle. Doctor H. A. Jones and Doctor F. J. Stevenson of the Bureau have rendered the potato growers inestimable service in this cooperative project. All of the new seedlings tested for disease resistance originate in this program.

laborious and time-consuming. Symptoms of this disease show only in mature or nearly mature plants or tubers. It happens frequently that susceptible plants do not contract the disease in a particular season. In order to make sure of resistance, therefore, a variety must be tested for two or more years.

DISEASE-FREE SEED STOCKS. The only hope for the immediate future, so far as the control of ring rot is concerned, is in the maintenance of seed stocks of our present varieties free from the disease. Stocks which are now known to be free from it should be guarded carefully through rigid methods of sanitation. Containers used to haul potatoes off the farm should be disinfected thoroughly before they are used for transportating seed stocks. Visitors to the farm during the growing season should not be permitted in the fields intended for seed stock production if by any chance they have visited other potato fields. The Experiment

FIG. 2. Spaulding Rose potato plants showing typical bacterial ring rot symptoms in the field. The plant on the left is slightly affected as evidenced by some chlorosis in the upper leaves and a slight wilting in some of the leaves. The one on the right has an advanced stage of the disease.

Station has laboratory facilities for expert diagnosis of ring rot in tubers suspected of this disease. Samples may be sent either to Aroostook Farm, Presque Isle, or to the Experiment Station, Orono, and will be checked free of charge. Approximately 150 samples were received last season, mostly from farmers in Aroostook County. The ultraviolet lamp was employed by Reiner Bonde and A. Frank Ross this year in order to test its effectiveness as an aid in eliminating affected tubers from seed stocks. A high percentage of the infected tubers can be removed by examining cut surfaces under the rays of the ultraviolet lamp. It was found, however, that 0.2 to 0.6 per cent of the affected tubers escaped detection by this method while 2.0 per cent escaped detection without the use of the lamp. The 0.2 per cent, however, is just that much too much to leave in any potatoes intended for planting. In case it is necessary for a grower to use stock which is known to have ring rot, he could remove a high proportion of the infected tubers with the use of an ultraviolet lamp if one were available. The removal of most of the infected tubers will be a help but will not be a cure.

SEED PLOTS. A seed plot method has been devised by Reiner Bonde which, so far as the test has gone, shows considerable promise for growers who wish to start with new seed stock and who are unable to purchase for their entire planting. Ring-rot-free seed stock should be obtained sufficient to plant about one-hundredth of the total farm potato acreage. This stock should be planted first and all containers and equipment for hauling, cutting and planting should be carefully disinfected before they are used for this stock. A plot should be selected on which potatoes were not planted the previous year. In all field operations on this plot, the equipment should be disinfected before it is taken into the plot. The grower himself should not go into the plot after having recently gone through his other fields. The plot should be rogued to remove leafroll and other diseases for which roguing is helpful. The roguing operation can be more effective if the plot is tuber-unit planted. One-tenth of the seed plot should be early-harvested to provide stock for planting the same size of plot the next year. The potatoes from the balance of the area should be harvested and stored in disinfected bins. It is desirable to store this seed in barrels which can be covered during the storage period. This stock

FIG. 3. Tubers showing external symptoms of bacterial ring rot. The four upper tubers show typical cracking in the Green Mountain variety. The two lower tubers show darkened discolorations beneath the periderm in the Irish Cobbler variety.

will be for an increase plot the second year which should be an acreage about one-tenth that of the total potato acreage. The third year of this program should see the entire farm planted to ring-rot-free seed stock. Should this method prove effective the ring rot disease could be eliminated entirely from the State within three years provided every grower adopted the plan and followed it conscientiously.

FIG. 4. Cut tubers showing different stages of vascular discoloration and decay caused by bacterial ring rot.

RING ROT IN SOIL. The ring rot organism apparently will not overwinter in the soil. It was found, however, by Reiner Bonde that it would carry over the winter in infected tubers which

developed volunteer plants. Diseased Katahdin potatoes were planted in 1940 during the harvest season. The tubers were put in trenches about six inches deep and covered so that the surface was fairly level. Part of each lot was covered further with a shallow layer of weeds and potato tops. Plants from the diseased tubers did not emerge until the first week in August, 1941, and growth of the plants was much retarded. Of the diseased tubers planted, 65 to 82 per cent survived and produced plants, and 42 to 57 per cent of the tubers planted produced plants with ring rot. (See Table 1 in the Appendix.) Volunteer potato plants were found in several commercial fields. In two fields, ring rot infected plants were found which had come from diseased tubers left in the field during the previous harvest season. These data are the basis for the recommendation that seed stocks free from ring rot should be planted on land which was not planted to potatoes the previous year.

DISINFECTANTS. Numerous chemicals have been tested for their effectiveness in disinfecting cut seed, containers, machinery, and storage bins. The acid mercury dip solutions acidulated with either hydrochloric or acetic acid (1 part corrosive sublimate in 500 parts water and .2% acid) were the most effective of all materials tried. Copper sulphate (1 pound in 10 gallons of water) was very effective in killing the ring rot organism on potato bags. Bordeaux mixture was not as effective as copper sulphate even when the copper strength of the two was the same. Coal tar disinfectants with a phenol coefficient of 6 were only fairly effective when used at a dilution of 1 quart in 50 gallons of water. Formaldehyde (1-120), Semesan Bel (1 pound in 7.5 gallons of water), and a number of other chemicals were shown to possess some value in controlling ring rot. Chlorox, a trade product containing 5.25 per cent by weight of sodium hypochlorite, was not effective for seed-piece disinfection when used in a concentration of 1-10 for periods up to 30 minutes.

In the process of treating storage bins and equipment used for marketing potatoes, care should be taken to remove dirt from the surfaces to be treated before the disinfectant is applied. It takes more disinfectant to wet a lot of dirt than it does to wet a relatively clean surface. Mercurial disinfectants may cause corrosion of exposed iron parts of machinery, and the removal of the mercury by the iron weakens the disinfectant solution.

Leafroll (Net Necrosis). Leafroll is a virus disease and is spread, very largely at least, by aphids. There are two general approaches to the control of this potato disease. One approach is through the development of resistant varieties and the second is through the production of seed stocks which are free, or practically free, from the leafroll disease in present varieties. Absolute freedom from this disease may not be attainable with susceptible varieties except under ideal conditions. Maximum yields of potatoes in Maine are assured, however, if the leafroll content of seed stocks is kept below 10 per cent.

RESISTANT VARIETIES. Potato varieties resistant or immune to leafroll are a definite possibility. Several thousand new seedlings[2] have been tested by Donald Folsom for resistance to leafroll in plots at Highmoor Farm; 2200 of the new seedlings were planted for the first time in 1941. Of all the seedlings exposed to the test from 1938 through 1940 only 6 came through the 1938 and 1939 test with clean readings and only one of these 6 remained apparently healthy in 1941. There are, however, 19 other seedlings which survived the exposures of 1939 and 1940 and remained apparently healthy in 1941. These 20 seedlings, 1 with 3 years' exposure and 19 with 2 years', certainly have considerable resistance to leafroll and some of them, as judged from appearances, have both satisfactory vines and tubers. Preliminary, small-scale cooking tests of these 20 in comparison with Green Mountains and Chippewas showed some to have promise for table stock quality. The next question is, will they produce barrels of potatoes per acre?

GOOD SEED STOCKS. The development of seed stocks which are free from the leafroll disease in susceptible varieties is a tedious process and one requiring care and close attention to detail.

ISOLATED PLOTS. The Station operates an isolated seed plot of about eight acres in the town of Winterville. Small quantities of all the potato varieties most commonly grown in Maine are carried in this plot and some progress has been made in obtaining

[2] The Station cooperates with the Bureau of Plant Industry of the U. S. Department of Agriculture in its potato breeding program, a portion of which is carried in Aroostook County. The Bureau field headquarters in Maine are at Aroostook Farm, Presque Isle. Doctor Henry A. Jones and Doctor Fred J. Stevenson of the Bureau have rendered excellent service to Maine in this program in their recognition of the important disease problems and in modifying the potato breeding program to best serve these needs.

A B

FIG. 5. Looking ahead between Chippewas (A) which became 90 per cent leafroll in one year at Highmoor Farm, and Seedling X247-24 (B) which is still free of leafroll after several years' exposure at Highmoor Farm.

seed stocks with very low leafroll infection. All new seedlings with promise are planted in this plot so that they can be increased under conditions as favorable as possible for the production of clean seed. The Florida readings for leafroll on Sebagos, Houmas, and Katahdins from the Winterville plot of 1941 were .7, .5, and .3 per cent respectively. Greenhouse checks showed Chippewas had 2.0 per cent and Pontiacs had 1.5 per cent leafroll. The goal, of course, on these seed stocks is a zero reading for this disease. Potatoes raised in this isolated plot are offered for sale first to the growers of foundation seed.

FOUNDATION SEED PROGRAM. This program is sponsored by the Station and closely supervised by G. W. Simpson and W. F. Porter. It has had a reasonable success. The Foundation samples in 1939, the first year for Foundation samples, averaged 1.5 per cent leafroll in the Florida readings and in 1940, 3.7 per cent. In 1939, 11.4 per cent of the samples in this test were without leafroll and in 1940, 9.6 per cent. The average leafroll for the samples from this program in the 1941 test was .9 per cent and 12.5 per cent of the samples showed no leafroll. The average for all other

samples in the Florida readings was 4.3 per cent leafroll and only 1.4 per cent of the samples were without this disease. The average Foundation seed stock, therefore, has been consistently better than the average of other seed stocks represented in the Flordia Test plots.

FLORIDA TEST. The certified seed program conducted by the State Department of Agriculture is an important item in the program for the production of good seed stocks in potatoes. In view of the serious spread of leafroll in the 1937 crop the Station in cooperation with the State Department, as an aid to the certified seed growers, undertook a Florida Test as a means of locating any reasonably good seed stocks that might be left in the State. This program was supervised by Reiner Bonde and Donald Folsom of the Station and E. L. Newdick of the State Department of Agriculture. There were 102 samples in this first test which was conducted in the vicinity of Hastings, Florida, during January and February in 1938. In later years the test has been conducted in the vicinity of Homestead. This program has become increasingly popular and 450 samples were entered in the 1941 test. The varieties entered were Bliss Triumph, Chippewa, Earlaine No. 2, Green Mountain, Houma, Irish Cobbler, Katahdin, Pontiac, and Warba, and the samples taken represented slightly over 5,000 acres. The Green Mountain variety led the list with slightly over 2,000 acres represented. Slightly over 2,300 acres represented had 2 per cent or less leafroll and 3 per cent or less mosaic. The stock with a reading of 2 per cent or less is considered reasonably satisfactory at present for use in growing certified seed. The potatoes produced on the 2,300 acres represented by these samples would plant in the neighborhood of 25,000 acres. Samples with readings of over 2 per cent but with less than 10 per cent represented a little over 2,040 acres. (Data on varieties and acreage are given in Tables 2 and 3 in the Appendix.) If the seed stocks from the acreage showing 10 per cent or less of leafroll were all planted in Maine they would be sufficient to plant about 25 per cent of the potato acreage.

APHID CONTROL. Aphids carry the leafroll virus from diseased plants to healthy ones. If means could be found to eliminate the aphid as a carrier there would be, so far as is known, practically no spread of this virus disease. It is known that aphids are rather

closely restricted as to plants on which they feed. Since annual farm crops are not available during the winter as a means of carrying the aphids through, they must overwinter on wild plants or perennial farm crops. The elimination of such winter hosts if they can be found and destroyed would end the war on these particular aphids. It is known that the buckthorn (*Rhamnus* sp.) and the rose (*Rosa* sp.) are overwintering host plants for aphids which feed on potatoes, and search is being made for other plants which serve this purpose. It is possible that potato growers in some areas may improve their situation by a removal of all of these overwintering host plants within an area closely surrounding their potato fields.

Considerable information is being obtained by W. A. Shands[3] and G. W. Simpson regarding the summer hosts and flight habits of the aphids which infest potato fields. There has been much controversy among the growers over whether or not the pea aphid will feed on potatoes. Altogether, 60 collections of insects were made in the 1941 season involving 4,822 aphids of which 1,281 were adults which could be exactly identified as to species. (Detailed data are given in Table 4 in the Appendix.) No adults of the aphid species which feed on potatoes were found on peas and no adults of the pea aphid were found on potatoes. The buckthorn aphid, the green peach aphid, and the potato aphid were the ones most numerous on potatoes. These three together with the pea aphid were all found on clover and, also, on young clover in fields from which peas had been harvested.

The hitherto unexplained increase in the number of winged aphids on potatoes, that has been observed in August, was traced to weed hosts. Among the numerous weeds found to be, or suspected of being, breeding hosts, wild rutabaga (locally "mustard") and wild radish (locally "kale") were found to be the most important during the summer of 1941. Plants growing in waste places and in potato fields where large leaves could develop were far more productive of winged aphids in August and September than were plants of the same species growing in grain fields. It was found that a single mature plant of the wild rutabaga or radish was able to mature sufficient aphids to provide one for each potato plant on one-seventeenth acre of potatoes. The weeds commonly known as "mustard" and "kale" are, therefore, a tremendous potential source for a build-up in the aphid infestation.

INSECTICIDE TRIALS. Methods for insecticidal control of the aphids infesting potatoes were continued during the summer of 1941 by T. E. Bronson[3] and G. W. Simpson on five farms in the vicinity of Houlton. Two plots approximately one-half acre in extent were provided on each farm[4] for each of five experimental treatments. These consisted of applications of the following mixtures[5]: (1) insoluble copper-derris spray with 2 quarts of soybean oil and a pint of a conditioning agent in each 100 gallons; (2) as in (1) except for the substitution of bordeaux mixture for the insoluble copper; (3) insoluble copper-derris-pyrophyllite dust containing 0.75 per cent of rotenone and 1 per cent of crude soybean oil; (4) as in (3) except for the substitution of monohydrated copper sulfate and hydrated lime for the insoluble copper; and (5) basic or tribasic copper sulfate on check plots for control of fungus diseases.

At three farms, tractor-powered sprayers were equipped with

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[3] The Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, is cooperating with the Maine Station in the aphid control program. W. A. Shands and T. E. Bronson are the representatives from the Bureau in this program. The assistance rendered by these two men is of inestimable value and their contributions to the aphid control program are hereby gratefully acknowledged.

[4] The cooperation of the following growers is gratefully acknowledged: Stanley Annett and Sons, Cleveland and Co., Fred Hagan, and Putnam Brothers Company.

[5] Formulae: (1) Insoluble copper-derris spray: A proprietary cuprous oxide 1½ pounds, derris 3 pounds (0.018 per cent of rotenone), crude soybean oil 2 quarts, a proprietary spreading and wetting agent 1 pint, in 100 gallons of water.

(2) Bordeaux-derris spray: Copper sulfate 10 pounds, hydrated lime 5 pounds, derris 3 pounds (0.018 per cent of rotenone), crude soybean oil 2 quarts, in 100 gallons of water.

(3) Insoluble copper-derris dust: A proprietary cuprous oxide (same as in (1)) 6.4 per cent, derris 15.6 per cent (0.75 per cent of rotenone), crude soybean oil 1 per cent, pyrophyllite 77 per cent.

(4) Bordeaux-derris dust: Monohydrated copper sulfate 20 per cent, hydrated lime 63.4 per cent, derris 15.6 per cent (0.75 per cent of rotenone), crude soybean oil 1 per cent.

Note: The ground derris root used in these experiments contained 4.8 per cent of rotenone and 16.7 per cent of total extractives. The dusts were mixed in a converted concrete mixer using stones. The conditioning agents were all atomized into the mixer while the materials were being blended.

10-row booms having 3 nozzles per row. These sprayers applied about 100 gallons of spray per acre per application at a fairly high pressure.

At two of the farms, horse-drawn traction sprayers were used, equipped with 6-row booms carrying two nozzles to the row. About 75 gallons of spray was delivered per acre per application and, as the nozzles were directed at the tops of the plants, the coverage of the lower leaves appeared to be less than that obtained by using a power sprayer.

On all farms the dusts were applied with a high-velocity power duster. Between 36 and 48 pounds of dust was applied per acre per application.

The aphid infestation was very light early in the season and the first insecticidal treatment was applied at the time for the second or third fungicidal coverage. From 3 to 5 applications of insecticides were made with the regular application of fungicides.

The effect of the insecticides on the aphid infestation was judged by the relative numbers of aphids surviving after the second application, when they were at their peak of abundance. On this basis, significantly fewer aphids, according to statistical analysis, survived in the plots to which derris was applied than in the plots to which only a fungicide was applied. The control of the aphid population ranged from a negative value to 96 per cent. Control was very good in some fields regardless of aphid species, the derris mixture applied, or the position of the aphids on the plants, but was unsatisfactory in other fields. Following the second insecticide application the percentage control was estimated as 64 per cent for the green peach aphid, 65 per cent for the buckthorn aphid, and 30 per cent for the potato aphid.

Field data showed that the plots treated with a fungicide plus derris produced significantly higher yields of potatoes than plots receiving only the fungicide. Each of the four derris treatments had about the same effect. The increase in yield on the derris-treated plots was 9.3 per cent or about 13 barrels per acre.

Samples from these plots were planted in the Florida Test and when the tubers were cut for planting a reading was taken on net necrosis. Tubers from derris-treated plots had 5.9 per cent with net necrosis and those from plots receiving only the fungicide had 8.0 per cent with net necrosis. At the time of the second reading for leafroll in the Florida Test plots, 32.9 per cent of the plants from

tubers from the check plots were diseased. For the plants from tubers of the derris-treated plots the percentages of leafroll were 31.6, 27.2, 25.7, and 25.5 for the application of derris-bordeaux spray, insoluble copper-derris dust, insoluble copper-derris spray, and bordeaux-derris dust, respectively. These figures indicate that in the 1941 season the use of either of the last two named insecticides was effective in reducing the spread of leafroll.

According to G. W. Simpson derris was used by a number of growers who entered seed plots in the 1941 Foundation Seed Program. The results obtained by these growers as compared with those from growers not using derris, suggests that the practice of early harvesting is much more effective in controlling leafroll than is the use of an insecticide. When derris is used the potato vines remain green later in the season. Insecticidal treatments are not effective in killing all the aphids and the ones left alive have more time during which to spread the leafroll virus if the potato vines are kept green. This is the explanation given by G. W. Simpson for the fact that these particular derris-treated plots had slightly higher readings in the Florida Test than did similar plots not treated with derris.

EARLY HARVESTING. The practice of "early harvest" has been employed for several years in the Foundation Seed Program. It is one of the most effective means of keeping the leafroll disease in check. In "early harvesting" the vines are pulled about the middle of August before the aphid infestation has become too great and before most of the disease that has been spread has had time to work down through the plant into the tubers. The results obtained on the various dates of harvesting in 1941 amply support the recommendation for "early harvesting" as a means of avoiding much of the spread of leafroll that may occur if vines remain green until normal digging time. Digging was begun on August 11 and samples were taken at two-week intervals until and including October 22. Samples were taken from two farms. The samples taken on August 11 developed 2.7 per cent of the potatoes with net necrosis on one farm and 20.1 per cent on the other farm. The potatoes dug on October 8 developed 11.9 per cent of net necrosis in the sample taken from the first farm and 55.7 per cent in the sample from the other farm. These samples were all stored at the 52° F. temperature so that the net necrosis which developed probably represents 80 or 90 per cent of the total spread of leafroll. On the first farm the

spread was more than tripled in the approximately two-month period from August 11 to October 8 and on the other farm it was more than doubled. (See Table 5 in the Appendix for complete data.) Duplicates of these samples stored at 36° F. had much less net necrosis, as would be expected. While the "early harvesting" results in a much lower yield of potatoes, it is effective in avoiding much of the spread of leafroll that normally occurs.

Serological, Chemical and Physical Tests. The killing of the leafroll virus in the tuber, or merely its inactivation, would be an effective method for controlling the disease. Various chemicals and heat are being tried by A. Frank Ross but to date the results have been negative.

Were it possible to identify the disease virus in the infected tubers with reasonable accuracy these could be removed from seed stocks. It is known that tubers with net necrosis do contain the leafroll virus. However, some of the potatoes with the virus do not show net necrosis, and none of the newer varieties such as Sebago, Houma, Katahdin, and Chippewa show the net necrosis although all are susceptible to leafroll. In the Green Mountain, 24 per cent of the tubers from hills that showed rolling of the leaves, apparently due to leafroll infection early in the season, later developed net necrosis. This indicates that net necrosis is not confined to late season infection. Some evidence was obtained indicating that the ratio of leafroll tubers to net necrosis tubers was influenced by fertilizer treatment. Several physical and chemical means for detecting the virus in tubers are being tried. So far none of these have proved entirely reliable although one test has shown some promise. Leafroll and healthy Chippewas react differently when stored for relatively long periods of time at 32° F. They differ in susceptibility to mahogany browning and in the tissues affected by this defect. This reaction may be useful in the separation of diseased from healthy tubers. The accuracy and the reliability of the method, however, are yet to be established.

Seed Source, Fertilization, and Culture. Net necrosis is a serious defect in table stock potatoes, and has been an important factor in the reduction of acreage planted to the Green Mountain variety. It would be helpful to table stock growers if some means could be found to prevent the development of this defect. This possibility is being kept in mind while attempting to develop seed stocks free of the leafroll virus.

SEED SOURCE. Potatoes from four fields were checked by Donald Folsom for leafroll spread in 1941, one field each in the towns of Hodgdon, Ashland, Mars Hill, and Westfield. Greenhouse tests in 1941-1942 showed that this disease had spread in all of these fields except the one in Ashland. The readings on net necrosis were 32 per cent, 0.5 per cent, 21 per cent, and 37 per cent, respectively, when the tubers were stored at 51° F. (See Table 6 in Appendix.) It was found also that when tuber samples from these fields were stored at temperatures optimum for net necrosis development, the net necrosis represented 95 per cent of the leafroll spread in 1941 for the field at Hodgdon, 75 per cent for the field at Ashland, 67 per cent for the field at Mars Hill, and 77 per cent for the field at Westfield. (See Table 7 in Appendix.) The storing of large quantities of seed stocks at temperatures favorable for net necrosis is not practical, of course. This method, however, might be used in a limited way to obtain a reading on leafroll content if it were found to give an accuracy of around 80 or 90 per cent, particularly in stocks suspected of having a rather high percentage infection.

CULTURE. The development of net necrosis in potatoes from the permanent plots at Aroostook Farm was correlated to some extent in 1941 with the previous crop and treatment, according to J. A. Chucka and A. Hawkins. Potatoes preceded by potatoes tended to show somewhat higher percentages of net necrosis than potatoes preceded by either crimson clover or corn. (See Table 8 in Appendix.) The differences among the various plots, however, were all too small to be of significance.

The time of harvesting the crop had a very definite bearing on the amount of net necrosis, the later the harvest the higher the percentage of net provided the vines remain green. (See Table 5 in Appendix.)

Tubers from plants sprayed with bordeaux mixture had, according to A. Frank Ross, 6.2 per cent of net necrosis as compared with 2.2 per cent in tubers from plots sprayed with Spergon, a non-copper spray. It is probable that the difference was due to the fact that the tops of the plants sprayed with Spergon died down earlier than did those sprayed with bordeaux. This conclusion checks with the results on early harvesting.

FERTILIZATION. Some fertilizers were found by J. A. Chucka and A. Hawkins to have a very definite effect on the development of net necrosis. Those containing muriate as the source of potash tended to produce potatoes with a higher net necrosis reading than did those fertilizers with potash from a sulfate source. Also, where the potash was all from the muriate the percentage of net necrosis increased as the potash in the fertilizer ratio was increased. It would appear to be the chlorine in the fertilizer that is the disturbing factor. Potatoes from plots fertilized with chemicals with no chlorine averaged 3.3 per cent net necrosis in 1941. Potatoes from plots fertilized with a mixture containing 8 per cent potash in the form of muriate averaged 9.3 per cent net necrosis. In the potash ratio test the net necrosis in the tubers from the various plots was .8 per cent, 6.2 per cent, 9.7 per cent, 8.0 per cent, and 11.6 per cent for 0, 4, 8, 10, and 12 per cent potash respectively. Other evidence that chlorine is the disturbing element is given in the "source of nitrogen" test. Potatoes from plots fertilized with ammonium chloride as a source of nitrogen had 25.7 per cent net necrosis in those from the unlimed portion of the plot and 29.7 per cent net in those from the limed portion. This compared with 12.2 per cent where nitrate of soda was used and 11.3 per cent and 13.3 per cent for limed and unlimed sections of the plot where ammonium sulphate was used. (See Table 9 in Appendix.) These results were obtained on Aroostook Farm plots. Any particular plot has received the same treatment since 1928. Results on two other farms did not check with those obtained at Aroostook Farm, there being little difference in net necrosis in potatoes on fields treated with a fertilizer containing the muriate or the sulphate of potash. (See Table 10 in Appendix.) It is felt, however, that the results on the Aroostook Farm plots are a more reliable indication of what can be expected over a period of years.

There is some indication, according to A. Frank Ross, that potatoes vary in leafroll infection to some extent with the amount of phosphate used in the fertilizer ratio. Potatoes from plots fertilized with 4-4-8, 4-8-8, and 4-12-8 produced plants with 12.5 per cent, 23.4 per cent, and 31.8 per cent, respectively, of leafroll. Should these results be verified by further tests they will be of some economic importance. Unpublished results from several years of study show that the phosphate in the fertilizer may be reduced from

8 per cent to 6 per cent without any loss in yields. Phosphates used in the fertilizer mixtures all contain some fluorine which is chemically related to chlorine.

Too much confidence should not be put in short period studies with fertilizers. The results indicating the effect of chlorides on net necrosis development, however, have checked reasonably well for two successive years. It is felt that one is safe in advising against chlorides in the fertilizers used for growing potatoes. Potash from other sources is just as effective from the standpoint of obtaining high potato yields. Also, the potatoes from plots fertilized with "pure chemicals" rank at the top in both cooking quality and starch content. The "pure chemical" fertilizer was made up of potassium nitrate, mono ammonium phosphate, and urea, there being no chlorine or fluorine in the mixture.

STORAGE TEMPERATURES. The temperature at which potatoes are stored has been found by Donald Folsom to have a very definite effect upon the development of net necrosis during the storage period. Potatoes stored at 33° F. showed 18 per cent of the tubers with net necrosis after 120 days in storage while those from the same field stored at 47° F. for the same period of time showed 40 per cent with net. Potatoes from another field had 15 per cent with net necrosis at the 33° temperature and 35 per cent at the 47° temperature after 154 days in storage. (See Tables 11, 12, and 6 in the Appendix.)

It was found also that potatoes held 10 to 30 days at 34° F. developed less net necrosis later at 47° F. than did those held for the full period at the higher temperature. A period of 30 to 90 days at the 34° temperature apparently conditioned the potatoes so that further development of net necrosis was much retarded or stopped entirely even when the bin temperature was raised to 47° F. (See Tables 13, 14, 15, and 16 in the Appendix.) These data suggest the possibility for materially reducing the percentage of net necrosis in table stock potatoes. If one can lower the temperature of his storage bin to around 33° or 34° F. soon after digging he will be able to reduce materially the net necrosis development in his stock. This procedure would enable many Green Mountain potatoes to grade U. S. No. 1 that otherwise could never make this grade. It was found also by Donald Folsom by careful checking that a potato with net necrosis usually had more than the 10 per cent waste permitted in U. S. No. 2 grade. (See Table 17

in the Appendix.) A cautionary comment should be made here relative to these low storage temperatures. They are helpful in controlling both net necrosis and stem-end browning in Green Mountains. Temperatures around 32° or 33° F., however, may cause Katahdins, Chippewas, and Sebagos to develop mahogany browning which is even more serious than net necrosis.

Stem-End Browning. Many attempts have been made to learn the nature or cause of stem-end browning. No one has been successful so far in connecting any fungus or bacterium with the development of this defect. Tests by A. Frank Ross disclosed that the concentration of latent virus is higher in stem-end browning tubers than in normal ones. It was found by further tests, however, that the latent virus was not the direct cause of stem-end browning although its presence in a potato stock may influence the amount of the defect to develop.

The serological test previously developed for the identification of stem-end browning has been studied further. The behavior of the test varies with the storage period and is most satisfactory about the time the defect develops in storage. During late winter and spring the test is complicated by the tendency of normal sera to give positive reactions.

The previous report that stem-end browning tubers contain less copper than do clear-fleshed tubers was not substantiated by the current year's results of ash analyses. Neither has any other chemical element been found in the tuber to be consistently associated with this defect.

Studies with insects failed to find any connected with the transmission of stem-end browning. Potato plots protected from insects produced tubers with 27 per cent of the defect and plots not protected had tubers of which 26 per cent had stem-end browning.

Checks by A. Frank Ross on the distribution of stem-end browning in the field disclosed that it was not uniformly distributed. In very few cases did all tubers in a single hill show the defect, usually only 1 or 2 being affected. There was some tendency for infected hills to be clumped.

Some evidence was obtained for the first time that stem-end browning seed stocks may produce a crop with more of the defect than is produced when clear-fleshed stock is planted. The averages for all plots of Green Mountains in the test were 7.3 per cent for clear-fleshed seed and 13.4 per cent for stem-end browning seed.

Similar tests with Cobblers gave negative results. The data indicate not only that there is a difference in stem-end browning and clear-fleshed seed but that seed from different sources responds differently under identical environmental conditions.

CULTURE. The Cobblers and Green Mountains grown in the Seed Spacing Variety Test on Aroostook Farm were examined for stem-end browning by A. Frank Ross. The Cobblers contained only 7 per cent stem-end browning and there was no correlation of the defect with seed spacing or size of tubers. On the Green Mountains, stem-end browning was correlated with seed spacing only on the plots where 1,000 pounds of fertilizer was added per acre. Spacings of 6, 9, and 12 inches resulted in 30.3, 41.0, and 49.5 per cent stem-end browning respectively. When fertilizer was applied at the rate of 1,250 or 1,500 pounds per acre there was no such correlation. There was, however, a correlation between tuber size and amount of stem-end browning. The Green Mountains were graded into four sizes, small, medium, large, and extra large. The averages of stem-end browning for these sizes were 25 per cent, 52.2 per cent, 64.8 per cent, and 67.5 per cent respectively. This relationship held regardless of seed spacing or fertilizer application. These results are in conflict with previous data, hence it appears that the correlation between incidence of stem-end browning and tuber size may vary from year to year.

The percentage of stem-end browning apparently varies to some extent with the time the potato crop is harvested. Samples from two fields were dug at two-week intervals in 1941 beginning August 11 and ending October 22. In the samples from one field the stem-end browning varied from 7.5 per cent for the August 11 harvesting to 18.7 per cent for the October 8 harvesting. In the other field the variation was from 6.4 per cent for the August 11 harvesting to 23.0 per cent for those harvested on September 8. These samples were all stored at 52° F. which is considered about the optimum for stem-end browning development. (See Table 5 in the Appendix.)

FERTILIZATION. The percentage of stem-end browning appeared again in 1941 to be correlated with the use of certain fertilizers. Samples from all of the fertility plots at Aroostook Farm were stored at around 50° F. In samples from plots fertilized with "pure chemicals" the highest reading of stem-end browning was 3.6 per cent. This fertilizer had no chlorine in it, being made up of potassium nitrate, mono ammonium phosphate, and urea. Potatoes

from the plot fertilized with a 4-8-12 fertilizer showed 48.2 per cent with stem-end browning. In this fertilizer the potash was all supplied from potassium chloride. In the potash ratio test the potash ranged 0 per cent, 4 per cent, 8 per cent, 10 per cent, and 12 per cent in the ratios. Potatoes from these plots had .5 per cent, 3.6 per cent, 21.4 per cent, 20.9 per cent, and 48.2 per cent respectively with stem-end browning. The potash here was all from potassium chloride. In the Sources-of-Nitrogen Test ammonium chloride produced potatoes with 20.2 per cent stem-end browning on unlimed portions of the plot and with 31.3 per cent on the limed portion. Sulphate of ammonia produced potatoes with 7.3 per cent and 17.4 per cent on the unlimed and limed plots respectively. The reading on the nitrate of soda plot was 15.6 per cent of stem-end browning.

Where potassium sulphate and potassium chloride were directly compared the potatoes from the sulphate plot unlimed had 4.7 per cent stem-end and on the limed portion 4.8 per cent. The readings on the potassium chloride plot were 12.0 per cent on the unlimed portion and 23.6 per cent on the limed portion.

Also, in the Rate-of-Application Test where the potash was all from the muriate the percentage of stem-end browning increased as the amount of fertilizer applied per acre increased. The readings were 1.6 per cent for no fertilizer, 9.6 per cent for 1,500 pounds, 21.4 per cent for 2,000 pounds, 24.8 per cent for 2,500 pounds, and 29.8 per cent for 3,000 pounds per acre. (See Tables 8, 9, 10, 18, and 19 in the Appendix for detailed data.)

There is, therefore, considerable evidence to indicate that chlorides in the fertilizer are a definite stimulus to the development of stem-end browning. The results given above point directly to this conclusion. Other results are not so clear in their indications. Tests on commercial farms are not as clear cut against the chlorides. It is felt, however, that the Aroostook Farm plots provide the most dependable data since these have received the same treatments for a long period of time. Further, all the results obtained in tests with fertilizers indicate that either the sulphate or the nitrate of potash, or a combination of the two, is just as effective a source of potash as the muriate from the standpoint of maintaining potato yields.

STORAGE TEMPERATURES. The temperature at which potatoes are stored is very definitely a factor in the development of stem-end browning. This defect varies from one field to another as was shown by Donald Folsom where potatoes from four fields were

compared during the winter of 1941-1942. This variation from one field to another frequently may be greater than the variation found at different storage temperatures. Nevertheless, potatoes from one field which developed 47 per cent of stem-end browning at 60° F. showed only 10 per cent when stored at 33° F. Apparently, the first 60 days of the storage period is the most critical for this defect. Potatoes held at 33° F. for 120 days developed 13 per cent stem-end browning while those held for 60 days at the 33° temperature and then shifted to a 52° bin for another 60 days had only 14 per cent of the defect. When held for 30 days at the low temperature and 90 days at 52° the reading was 23 per cent. However, it should be noted as indicated above that these potatoes developed 47 per cent of this defect when held at the 60° temperature throughout the storage period. Potatoes from another field which had 9 per cent stem-end browning at 60° F. had only 3 per cent at the 33° temperature. (See Tables 6, 13, 14, 15, 16, 20, and 21 in the Appendix for detailed data.) On the basis of these data and similar data in past years, therefore, it is recommended that the storage temperature for Green Mountains and Cobblers be brought down to around 33° F. just as soon as possible after digging time. In most storages the lowering of the temperature may possibly be speeded up with the use of a fan or blower at night when the air is cooler outside than inside the storage. A study is being made on this point using a thermostatic control that can be set to shut off the blower automatically when the storage reaches the desired temperature. The blowers, however, can be controlled by hand. Potato varieties such as Chippewa, Katahdin, Sebago, and Houma should not be cooled below around 36° F. since they develop mahogany browning at temperatures around freezing or slightly above. Since these newer varieties do no develop stem-end browning anyway there is no object in keeping them at extremely low temperatures.

Purple Top. The purple top disease continues to be a serious problem. Many specimens of suspicious plants have been brought in for diagnosis. Unfortunately, practically nothing is known regarding the cause of this disease. In fact there seems to be two diseases with symptoms of purple top, one which does not affect the seed quality of the tubers which grow normally and the other which affects materially the seed tubers.

About 80 fungus and bacterial cultures have been isolated by Reiner Bonde from hills affected with purple top and these are be-

ing tested regarding their pathogenicity on potato plants and their effect upon the plant.

The suspicion that rhizoctonia had some connection with this disease has, so far, not been substantiated on the basis of experiments to test this point.

So far no organism has been identified as the causal agent. The disease apparently affects all varieties but has been most prevalent in Katahdins and Sebagos. Tubers from plants affected with current-season symptoms of purple top are not suitable for seed purposes since they produce only weak plants if they grow at all. The tubers obtained from these weak plants, however, will produce nearly normal plants and tubers the following year. Tubers from purple top hills appear to grow normally provided they are dug early before the symptoms become pronounced.

Rhizoctonia. Treatments of seed potatoes by the acidulated mercury dip method were studied by Reiner Bonde and Bernie Plummer, Jr., to determine the effect of a reduction in the amount of acid in the dipping solution on its effectiveness in the control of rhizoctonia and on its retention of the mercury content after successive treatments. The standard formula requires 1 per cent of acid and 0.2 per cent mercuric chloride. The results of the 1941 studies indicate that the acid content of the solution can be reduced to 0.25 per cent without materially affecting the rapidity of loss of mercury with successive treatments or the solution's effectiveness in controlling rhizoctonia. The results show also that citric acid may be substituted for hydrochloric or acetic acid in the acidulated mercury dip solution. There was some evidence in 1941, however, to indicate that a treating solution prepared with acetic or citric acid is somewhat less effective in controlling rhizoctonia than is a solution acidulated with hydrochloric acid.

Mahogany Browning. Internal mahogany browning of potatoes is a low-temperature injury. There is some evidence to indicate that the presence of the leafroll virus in the tuber aggravates this injury in Chippewas and also results in a localization of the discoloration in the cortex of the tuber. This was discovered in studies by M. T. Hilborn and Reiner Bonde in which potatoes stored at 32° F. and at 36° F. at digging time were examined each week during the storage season. The first appearance of mahogany browning was about the middle of January. After that time the percentage of affected tubers increased to almost 100 per cent in

Chippewa which is a susceptible variety. None of this defect was found in Green Mountains stored at 32° F. or in Chippewas stored at 36° F. It would be considered good judgment, therefore, to keep the storage temperature at 36° F. or slightly above for Chippewas, Katahdins, and possibly some of the other new varieties.

Late Blight. Late blight continues to be one of the most troublesome potato diseases in this State. This disease was very severe in Aroostook County in 1941 and the loss caused by it was relatively great. A rather limited survey made during the second and third weeks of September indicated that more than half of the fields were badly infected with late blight. The disease was practically absent on a few fields which in all cases had been well sprayed throughout the season. Data secured during the harvesting season from the farms of one township indicated that approximately 5 per cent of the crop was left in the field on account of tuber decay caused by late blight. A few fields had nearly 25 per cent of the tubers infected with late blight decay. It has been estimated that about 10 per cent of the crop was lost in 1941 because of infection by this disease.

The control of late blight is a major problem for the farmers of Maine and large losses are still experienced in spite of large expenditures made for the purchase of fungicides. A curtailment of the supply of copper fungicides because of the war surely would cause much anxiety for the potato growers. It is quite possible that some growers might make more efficient use of the fungicides which they buy, in one way or another, as will be indicated.

Late blight infection was found in several places in the experimental spray field on Aroostook Farm on July 23 and climatic conditions were favorable for the general spread of the disease throughout most of the season. The plots received seven or eight spray applications during the season and the disease was well controlled by all of the copper fungicides that were under trial.

COPPER-SPRAY FUNGICIDES. The various copper fungicides for the control of early and late blight were tested by Reiner Bonde on the Houma variety in 1941 since it is considered to be even more susceptible to late blight than the Green Mountain. The disease was very prevalent in these experimental plots in 1941 so that the conditions were favorable for comparing the fungicidal efficiency of the different materials. The plots received seven applications of spray during the season, these being applied with a horse-drawn,

wheel-traction machine carrying two nozzles per row. The sprayer applied approximately 100 gallons per acre per application.

The plots treated with bordeaux mixture were considered as check plots in all comparisons including the yields per acre since this treatment has been the standard one for years. Yellow cuprocide, when used at the rate of 1 pound in 100 gallons of spray material, appeared to be the least effective of the fungicides under trial.

Plots receiving copper hydro arsenate and copper hydro arsenate-ite for blight control yielded four and five barrels respectively more per acre than did the plots treated with bordeaux. Field observations on the development of late blight infection revealed that these two materials were very good fungicides as compared with the others that were under trial. They also apparently possess some insecticidal properties and it is possible that part of the increase in yield resulted from the control of insects, particularly the Colorado potato beetle and flea beetles. Copper hydro arsenate and copper hydro arsenate-ite may prove of considerable value for spraying potatoes provided these materials can be sold on the market at a favorable price. The fact that they contain a relatively low percentage of metallic copper is in their favor, especially at a time when the supply of copper may be limited. It is possible also that these two materials may control the potato beetle satisfactorily, in which case it would not be necessary to use calcium arsenate for this purpose.

MODIFIED BORDEAUX MIXTURES. Bordeaux mixture prepared according to the 10-10-100 formula was for a number of years recommended for spraying potatoes in Maine. More recent work by Reiner Bonde has shown that the lime content in the bordeaux formula can be profitably reduced to one-half resulting in the 10-5-100 formula now being recommended. The possibility that blue vitriol and fungicides containing copper may become scarce in the near future has raised the question as to whether the copper content as well as the lime used in making bordeaux can be reduced without endangering the crop from late blight attack under Maine conditions.

An experiment was conducted in 1941 for the purpose of determining the effect on yield and late blight control of spraying Green Mountain potatoes with bordeaux prepared according to different formulae. A two-nozzle-per-row, horse-drawn, wheel-traction spray rig was used for applying the materials. The plots received

7 applications of spray during the season and approximately 100 gallons of bordeaux was applied per acre per application. The formulae tried were 10-10-100,[6] 8-8-100, 8-4-100, and 10-5-100.

The yields from the plots sprayed with the different concentrations of bordeaux mixture were quite similar so that no particular formula stood out as superior to any other.

Early and late blight were controlled equally well by all concentrations of bordeaux mixture under trial. Both diseases were very severe in the unsprayed controls and in field plots located nearby. The results of this single test indicate that the copper sulphate in the bordeaux formula may be reduced 20 per cent with no significant reduction in the yield of potatoes. This would be especially true on farms where good spray equipment is employed and where the fields are kept well covered with spray material. It is the opinion of Reiner Bonde that the time of application together with the maintenance of a good coverage of spray material at the critical period for late blight are more important, within limits, than the particular bordeaux formula that is used.

ORGANIC SPRAY FUNGICIDES. Certain organic non-copper-containing materials were under trial again in 1941 for their possible fungicidal properties and their usefulness in the control of late blight. One material which appeared to be promising in the 1940 season appeared again in 1941 to have considerable fungicidal value. It did not control blight late in the season, however, when the weather conditions were most favorable for the spread of the disease and therefore the potato yield was seriously reduced in the plots treated with it. The plots sprayed with bordeaux yielded 157 barrels per acre in comparison with 141 barrels per acre for another of these fungicides.

Aphids and other insects were not plentiful in the plots included in this experiment; therefore it was impossible to determine whether the organic material possesses insecticidal properties.

COPPER FUNGICIDES COMBINED WITH ROTENONE. The prevalence of leafroll and net necrosis in many fields of potatoes recently grown in Aroostook County has made it desirable to attempt to reduce the aphid population in the field with an insecticide. There is more economy of labor if the fungicide and the insecticide can be applied in one field operation. Experiments were con-

[6] Copper sulphate, lime, and water respectively.

ducted in 1941 by Reiner Bonde and G. W. Simpson to determine whether or not rotenone is compatible with certain commonly used copper fungicides, and whether or not such a combination spray formula is practical.

The plots were sprayed with a tractor-power-take-off machine and received eight applications for the season. Rotenone, in the form of ground derris root, was added to all spray applications except the first one. The fungicides under trial were bordeaux 10-10-100, bordeaux 10-5-100, Basi-cop 5-100, spray-cop 6-100, and yellow cuprocide 1.5-100.

The yields obtained from plots receiving the different treatments are summarized in Table 24 in the Appendix. The addition of rotenone to the fungicide spray resulted in an increase of from 9 to 17 barrels of potatoes per acre.

Spraying with rotenone in combination with a copper fungicide can be expected to result in an increased yield of the crop sufficient to pay for the added cost of the insecticidal materials. Its use may not, however, reduce the insect population sufficiently to lower the amount of spread of leafroll and other virus diseases. Further work should be done to test other fungicidal and insecticidal combinations for their ability to reduce the amount of disease spread. It is possible also that the equipment could be improved from the standpoint of its efficiency in the application of fungicides and insecticides.

DUST-OIL VAPOR FUNGICIDE AND INSECTICIDE. An experiment was conducted in 1941 by Reiner Bonde and G. W. Simpson to test the efficiency of a "Dust-Oil Vapor" fungicide and insecticide in controlling the blight diseases and insects. The machine for applying this material is known as a "Vapo-duster," is manufactured by the Root Duster Company of Cleveland, Ohio, and was supplied to the Station by the California Spray Chemical Company of Elizabeth, New Jersey. With this equipment the copper-containing dust is expelled by tractor power with force into the potato foliage through one set of openings on the spray rig and the oil mist through another set of openings. This oil may contain an insecticide in the form of a combination of extracts of rotenone and pyrethrum and aids in making the dust adhere to the foliage.

The plots received six applications of the combination of fungicide and insecticide the first being made on July 23, when an

occasional lesion of late blight could be found in the plots. The treatments given were dust and oil, dust and oil plus an insecticide, bordeaux 10-5-100, and bordeaux plus rotenone. The first three materials were applied with the "Vapo-duster" and the last was applied with a tractor power sprayer.

The yield rates for the treatments which included an insecticide were significantly greater than for those without the insecticide. The plots treated with bordeaux 10-5-100 without an insecticide gave the lowest yields of all. The difference in yield rate between the two series of plots treated with bordeaux and the corresponding dusted plots might have been due to some extent to the differences in plant injury caused by the machines making the applications. The wheels of the "Vapo-duster" outfit apparently caused less plant injury than did those of the regular spray rig. The insecticide applied with the "Vapo Dust" increased the yield 7 barrels per acre and rotenone added to bordeaux increased the yield 14 barrels per acre.

On Aroostook Farm, both the "Vapo Dust" and bordeaux gave good control of late blight, in spite of the fact that a trace of infection was present when the experiment was begun. The dusted plots began to mature approximately a week before those that were sprayed. The plots that received the insecticide in addition to the fungicide remained green somewhat longer than did those which did not receive the insecticidal applications.

Experimental data on studies in late blight control are given in Tables 22, 23, 24, and 25 in the Appendix.

GREEN MANURE CROPS

Eight different crops (sunflowers, corn, millet, buckwheat, sudan grass, crimson clover, oats, and soybeans) were compared by J. A. Chucka and J. L. Harrington as annual green manure crops for potato rotations on four farms in central Maine. The yield for these crops in organic matter produced, as an average for the four farms, ranged from 7,686 to 3,706 pounds per acre. The crops ranked in yield in descending order as listed above with sunflowers yielding the highest. Several fertilizer treatments are being compared on two of these farms on a fairly large area each of corn and millet. Applications of fertilizer were made both in the

spring prior to seeding and again in the fall when the crops were plowed under. These areas are to be planted to potatoes in the spring of 1942 and potato yields will be taken to determine the relative value of the various fertilizer treatments.

At Aroostook Farm, crimson clover and field corn are being compared as green manure crops in a two-year rotation and these are being compared with potatoes grown every year. Two levels of fertilizer application (1,000 and 1,500 pounds per acre of an 8-16-20) are being used on these plots. On some of the plots in the two-year rotation all of the fertilizer is applied to the potato crop and none to the green manure crop. On other plots part of the fertilizer is applied to the green manure crop and the remainder to potatoes. These plots were started only two years ago and should be continued for several more years before attempting to judge either the value of growing a green manure crop or the proper time or place of applying the fertilizer. However, it may be of interest to report the results obtained thus far. Corn produced roughly twice as much organic matter as did crimson clover. Corn also responded to fertilizer added to the green manure crop to a much greater extent than did the crimson clover. Potato yields following either corn or crimson clover were higher than those following potatoes. Thus far, however, yields of potatoes following crimson clover were somewhat higher than those following corn in spite of the fact that more organic matter was turned under where corn was used as a green manure crop. Also, potato yields were somewhat higher where all the fertilizer was applied to potatoes and none to the green manure crop than they were where part of the fertilizer was applied to the green manure crop and the remainder to the potato crop.

It is possible that better results might be obtained from the use of corn or other nonlegume green manure crops if more nitrogen were applied either in the growing of the green manure crop or at the time it is turned under.

FERTILIZERS

Permanent Plots. All treatments on the permanent plots at Aroostook Farm produced higher yields in 1941 according to J. A. Chucka, A. Hawkins, and J. L. Harrington than were secured during each of the three preceding years. Differences in yield

among the various treatments were in general the same as in previous years. The plot yields again indicated that more phosphoric acid is being used in potato fertilizers than is necessary to obtain maximum yields.

Potash Source and Ratio. Three different sources and four different rates of potash were compared in a test conducted on two farms in Aroostook County in 1941. The fertilizers with 10 per cent potash produced slightly higher yields than did the fertilizers with 8 per cent potash. Raising the potash above 10 per cent did not increase potato yields. Fertilizers with sulfate of potash and with combination sources of potash produced somewhat higher yields than did fertilizers with muriate of potash as the only source of potash.

Hi-Lo Fertilizer Placement. The standard band placement of fertilizer was compared with the so-called Hi-Lo placement using two grades of fertilizer and two rates of application on two farms in Aroostook County. The Hi-Lo placement consisted of placing one band of fertilizer at about the level of the seed piece and the other band two or three inches below it. In this Hi-Lo placement the amount of fertilizer placed in the two bands was equal in one treatment and unequal (¼ in the upper band and ¾ in the lower band) in another treatment. None of these variations in placement produced a significantly higher yield than the standard placement method. The fertilizers used were 8-16-20 and 8-12-20 and the rates of application were 1,000 and 1,500 pounds per acre. The 8-12-20 fertilizer produced as high yields as the 8-16-20 or higher at both rates of application and in all placement methods. This substantiates the data from the permanent plots indicating that more phosphoric acid is used in potato fertilizers than is necessary.

Concentrated Fertilizer. Nine different 8-16-16 formulae were compared with one 4-8-8 formula. The 8-16-16 formulae varied in content of calcium, and in sources of nitrogen and magnesium, and the test was conducted on two farms in Aroostook County. The formulae without nitrate nitrogen tended to produce somewhat lower yields than formulae with other nitrogen sources although the differences were not significant. The variations in calcium content and variations in source of magnesium had no measurable effect on potato yields.

Starter Solution. Starter solutions consist of a relatively small amount of readily available plant nutrients added in solution directly to the seed or transplanted seedling. These solutions have been used with considerable success in recent years on such transplanted crops as tomatoes, cauliflower, and cabbage. Several rates of application on potatoes were tried on two farms during the past year, one in Aroostook County and one in central Maine. The results obtained indicate that some increase in yield of potatoes may be secured with the use of starter solutions but that the increase is too small to warrant the extra expense of these materials.

Fertilizer Rate and Ratio. A study was made comparing four rates of 8-16-20 and comparing grades of fertilizer varying in percentage of nitrogen, phosphoric acid, and potash. The test was made on three farms in central Maine. Due to the variation in the amount of rainfall in the areas where these tests were located the results obtained differed from one farm to another. In Waldo County the potato yields actually were lowered by increasing the amount of an 8-16-20 fertilizer applied at a rate above 750 pounds per acre. In southern Piscataquis County the yields secured with different amounts of fertilizer were about the same. In Penobscot County, at Lee, where ample rainfall came during the growing season, the potato yields increased with each increase in the amount of an 8-16-20 fertilizer applied. Approximately a 1-2-2 ratio of nitrogen, phosphoric acid, and potash produced the highest yields as an average for the three farms.

Data on the results of 15 years' study with fertilizers on the Aroostook Farm permanent plots are now in manuscript form and will be published shortly. A copy of this bulletin may be had upon request.

Absorption of Nutrients by Different Varieties of Potatoes. The time in the development of the potato plant when it uses the various fertilizer elements is important from the standpoint of the materials to be used in making up the fertilizer. Three years' results are available on studies made by Arthur Hawkins on the absorption of nutrients by four varieties of potatoes. In general it may be said that potato plants capable of producing upwards of 400 bushels (145 barrels) per acre, absorb about 120 to 160 pounds of nitrogen, 25 to 30 pounds of phosphoric acid, 200 to 250 pounds of potash, 60 pounds of calcium oxide, 30 pounds of magnesium

oxide, and about 10 to 12 pounds of sulfur in the process of producing this per acre yield.

The Green Mountain variety absorbed about 70 per cent of its total consumption of plant nutrient elements during the season between 50 and 80 days after planting. The earlier varieties, Cobbler and Chippewa, usually emerge and make more rapid growth early in the season than do the later-maturing varieties, and the period of more rapid absorption of nutrients occurred with these two varieties about one week earlier than for the Green Mountain variety.

Nitrification of Different Sources of Nitrogen. Urea nitrogen was found by Arthur Hawkins to be nitrified more rapidly than ammonium sulfate. This was true even if calcium carbonate ($CaCO_3$) was added to the ammonium sulfate mixture to the extent of balancing its equivalent acidity. Both compounds were found to nitrify more rapidly than the natural organic nitrogenous materials.

Movement of Nitrogen in the Soil. Nitrate nitrogen was found by Arthur Hawkins to be very mobile in the soil under field conditions, moving below or above the point where it was placed depending upon the movement of soil water. Following rains early in the season, nitrate nitrogen was found to move 4 to 6 inches below the point of application. During dry periods in July and August it moved upward to 8 inches above the position where it was placed (in bands to simulate field practice in potato fertilization).

SEED SPACING AND VARIETIES

The matter of seed spacing, or in effect the rate of planting, of potatoes is of considerable importance. Some varieties apparently give better performance when the seed pieces are planted relatively close. Since there is an increasing demand for seed stock having medium to small sized tubers, potatoes grown for seed probably should be planted closer than when grown for table stock.

Comparisons of the yielding ability of eight varieties of potatoes at three different seed spacings and at three levels of fertilizer application were made by J. A. Chucka, Arthur Hawkins, and J. L.

Harrington in 1941. The seed spacings used were 6, 9, and 12 inches. The rates of fertilizer application were 1,000, 1,250, and 1,500 pounds per acre of an 8-16-20 fertilizer. The test was conducted on Aroostook Farm, at Presque Isle, and on the Smith Farm, at Stillwater.

Considering the yields produced as an average of the three spacings and an average of the three rates of fertilizer applied, the range in field-run yields for the eight varieties at Presque Isle was from 184 to 138 barrels per acre. The rank of the varieties in descending order was Earlaine #2, Katahdin, Sebago, Chippewa, Warba, Houma, Green Mountain, and Irish Cobbler. On the same basis the yield range of the eight varieties at Stillwater was from 158 to 96 barrels per acre and the rank of the varieties in descending order was Earlaine #2, Chippewa, Sebago, Houma, Katahdin, Green Mountain, Irish Cobbler, and Warba. Relatively close spacings nearly always produce higher yields of field-run potatoes than do the wider spacings. This does not necessarily hold true, however, when yields are calculated on the basis of U. S. No. 1. When yields were based on U. S. No. 1 potatoes rather than on field-run such varieties as the Green Mountain and the Katahdin receive a relatively higher rank and such varieties as Houma and Warba receive a relatively lower rank. Data are given in Table 26 in the Appendix.

POTATO BY-PRODUCTS

Potato by-products, particularly starch, have been a substantial source of income to potato growers in Maine during recent years. It can be assumed that the sale of table stock and seed potatoes will continue to be the major source of income for the potato industry. The manufacture of potato starch and any other by-products that may be developed will, however, be of considerable value to the potato industry if these enterprises can be properly integrated. It is with this thought in mind that studies have been continued on by-products. An improvement in the quality of starch or an improvement in the methods of manufacture to increase the starch yields makes it possible for the manufacturer to pay the grower higher prices for potatoes for manufacture.

Starch Factory Potatoes. Thirty-eight samples of starch

factory hopper potatoes were examined by C. A. Brautlecht during the interval May 1, 1941, and April 30, 1942. The average starch content in samples for the season was 11.5 per cent. The maximum starch content was 15.8 and the minimum (all rotted culls) was 5.1. For the previous year the average was 13.4 per cent. The quality of culls and No. 2 or better potatoes going to starch factories this year was somewhat inferior to those of last season. There were fewer Mountains and Cobblers and more low-starch-waxy Chippewas. The Chippewas contained considerable mahogany browning. Dirt, adhering to the potatoes and removable by washing, was about as usual, from 0.1 to 1.0 per cent, the latter being found on dirty wet potatoes. The average dirt was about 0.2 per cent. Factories naturally get more of this dirt as more barrels are dumped. The greater amount of blighted potatoes and browned Chippewas and "mushy" potatoes made it more difficult to produce a good quality starch, especially in the "old batch" factories. There were very few good sound merchantable potatoes of 2 inch size or over in factory hoppers and relatively few small sound potatoes. Most samples contained cut and bruised potatoes, second growth, "bulls," "off shape," and sunburns. The sunburns and "bulls" contain a little less starch than normal average sized potatoes. Some samples had a high percentage of diseased "floaters" which contain little starch. Very little net necrosis and stem-end browning was found but there was noticeable injury from chilling and frost. Scab was present in most samples throughout the year and some rhizoctonia was present. Wilt or bacterial ring-rot was present, also, in small quantity in addition to late blight storage rot.

Starch Analyses. Analyses of 48 samples of starch were completed and the results are given as follows:

Much has been learned regarding the processing of starch in various factories, reasons for complaints on the part of users, and how many of the difficulties could be overcome. The industry is gradually working toward standards which have a definite meaning and value. Much thought has been given by starch manufacturers to the analytical figures obtained and many have established a goal at which to aim in their own efforts.

Other analyses made included three samples of water, one of sweet potato starch for comparison with that from white potatoes,

2 of dextrin, 2 of wet starches, and 11 samples of potato pulps both wet and drained. The potato pulps showed, after draining 24 hours, about 1.0 per cent mineral matter, 86 per cent water, about 0.16 per cent nitrogen (or 1.0 per cent protein), 2.0 per cent crude fiber, 9 per cent nitrogen-free extract (non-cellulose carbohydrate), and about 0.3 per cent crude fat. The pH of a water extract was about 6.2.

	Average	Maximum	Minimum
Moisture %	15.9	26.3	4.3
Total solids by difference %	84.1	73.7	95.7
Ash %	0.34	0.45	0.20
Starch (water free basis) %	94.3	100.0	90.5
Viscosity centipoises for 1% soln. in 0.6% NaOH	6.4	12.8	2.5
Granule size, av., mu.	32	42 from Mts.	23
Acid, quant. (cc 0.1 N NaOH per 25 g.)	2.6	5.4	0.1
Speck count, macro, 5 g. per dcm.	565	2010	35
" " x 3.5, ditto	735	2640	83
Sieve test (on powdered samples)			
100 mesh %	1.4	21.0	0.0
100 to 200 mesh %	2.5	24.2	0.0
(finer than) 200 mesh %	93.6	100.0	0.0
Bacteria (b. coli)	34+ 14—	5/5 in 0.01%	Negative
Reflectance (whiteness) %	93.3	98.1	88.4
pH (degree of acid)	6.7	7.3	6.2
Solubles %	0.21	0.37	0.01

Commercial samples of starch have been examined occasionally for fat, fiber, nitrogen, and protein. A fine quality starch is free of fat, fiber, and protein and nitrogen. Poor quality starches contain a little of these substances. Practically all potato starches have a slight potato odor which is due to a trace of oil which cannot be removed in the usual processing. A good quality starch also has a definite "feel" and "crunch" not as noticeable in poor quality starch.

Starch Potato Supply. Potato starch manufacturers started operations on the 1941 crop early in September. Not until the diversion program was available, however, did an appreciable sup-

ply of potatoes go to factories. This was near the end of September. The 1940 crop total diversion payment cars was reported as 13,402. There were probably 1,600 cars of non-diversion or cull potatoes of the 1940 crop that went to starch factories, making a total grind estimated at about 15,000 cars. There will probably be about 10,000 cars of the 1941 crop ground in a total of shipments with seed and table stock and starch potatoes of about 48,000 cars.

Starch Market and Price. The starch market has been very good. Some manufacturers turned down export orders because they could not supply their own regular customers. Although some were eager to push up the price, the better companies kept price down to as low a level as possible in order to keep their marginal buyers, so important under normal conditions.

NEW YORK PRICE IN DOLLARS PER POUND

		In car lots	In less than car lots
September 1941	Potato starch dextrin	0.0850	0.0950
April 1942	" " "	0.0950	0.1175
September 1941	Potato starch	0.0585	0.0710
April 1942	" "	0.0637	0.0760

Starch in storage, unsold, is at a low tonnage figure. During the spring of 1942, freight rates were increased by Federal edict and starch manufacturers had to increase New York and Boston prices to offset it.

Pulp Investigations. The work on waste starch factory potato pulp was carried on more intensively as soon as drained pulp was available. Dairy, sheep, cattle, and hog men were invited to get the pulp and to try it out. They were given some feeding rations, which had been checked by Professor Cairns of the College of Agriculture. Some potato growers were asked to try the pulp on their potato land. After the sulfur dioxide treatment of the pulp and thorough washing with well water, little if any disease should carry over. The waste potato pulp, upwards of 10,000 tons on a dry basis, should not go into streams but should be used as a cattle feed, or, at least, go back on the land.

German Potato Varieties. Ten varieties of German potatoes and Mountains, Katahdins, and Houmas were grown at Presque

Isle by Dr. Clark of the U. S. Department of Agriculture in a yield test consisting of five replications. Samples of these potatoes were analyzed for starch (see Table 27 in the Appendix). The starch content of the five replications was in good agreement. Although some of the German varieties contained 20.4 per cent starch, the Mountains contained 18.5 per cent and yielded a little more starch per acre (about 5,100 pounds) than did the best German variety (about 4,700 pounds). The Mountains also were the largest potatoes. There were no signs of disease in any of these thirteen lots of potatoes. The Katahdins and Houmas each contained 15.4 per cent starch and yielded 3,550 and 4,240 pounds starch, respectively, per acre.

ECONOMICS OF THE POTATO INDUSTRY

Farm Organization and Costs and Returns in Producing Potatoes in Central Maine, 1938. Farm returns, costs, and practices on three types of farms producing potatoes in central Maine were obtained by W. E. Schrumpf. Detailed information on farm acreage, crops, livestock, capital, receipts, expenses, and net farm income, as well as on all the costs and returns in potato production was obtained concerning the three types of farms producing pota-

FIG. 6. Typical potato harvesting scene in Aroostook County, Maine.

toes commercially in the area. An analysis of the data shows that the three types, on the basis of the proportions of cash income from the various farm enterprises, are potato farms, livestock farms, and general farms.

The farm acreage of all the farms averaged 255 acres of which 74 acres was cropland. Potatoes, hay, and grain were the principal crops supplemented by beans, sweet corn, and peas. There were, on the average, 8.3 acres of potatoes per farm on the livestock farms, 8.5 acres on the general farms, and 17.3 acres on the potato farms.

Dairy animals, which comprised most of the livestock, averaged 8 per farm on the potato farms, 12 on the general farms, and 20 on the livestock farms.

The farm income (the difference between the farm receipts and the farm expenses) was largest on the livestock farms in 1938, averaging $918 per farm compared with $607 on the general farms and $170 on the potato farms.

The cost to the farmer of growing, harvesting, storing, and selling potatoes was $1.36 per barrel on the potato farms, $1.54 on the general farms, and $1.74 on the livestock farms.

On the livestock farms, in 1938, the average farm income was larger than on the potato farms in spite of the fact that (because of higher yield rates and larger acreages) the per barrel cost of potatoes was smallest on the potato farms. On the livestock farms more efficient use was made of labor and capital than on the potato farms. The Maine farm price of potatoes in 1938 was about the same as the average of the 10 years prior to 1938. In general, on the potato farms an increase in the size of the dairy enterprise would have supplemented the farm income. On the livestock farms, on the other hand, higher yield rates and somewhat larger acreages of potatoes would have put the cost of production in more favorable relationship to the price received. The general farms were intermediate in these respects.

Costs of Producing Potatoes in Central Aroostook County, Maine, 1940. Information on the cost of producing potatoes was obtained by W. E. Schrumpf for 1940 on 178 farms in central Aroostook County. Partial analysis of the information obtained shows that trends in the area in relation to ten years ago, when a similar study was made, are (1) an increase of 16 per cent in the

potato acreage and of 14 per cent in the number of livestock per farm, (2) a decided shift from Green Mountain potatoes to other varieties, especially Katahdin and Chippewa (ten years ago the Green Mountain variety comprised 80 per cent of the potato acreage compared with 44 per cent in 1940), (3) a decrease of about 5 per cent in the proportion of farms using horses and a corresponding increase in the proportion using tractors and trucks, (4) a decrease of about 8 per cent in the amount of man labor in producing an acre of potatoes, and (5) a slight decrease in the cost of production.

FIG. 7. Unloading potatoes at farm storage.

Potato-Harvest Labor in Aroostook County, Maine, 1941. Labor at harvest time is one of the most important items in the management of a potato farm. The period of time for harvesting the crop is relatively short normally and unfavorable weather conditions may shorten it even more. Information representing 1,708 workers was obtained by W. E. Schrumpf and Smith C. McIntire[7] during the 1941 potato harvest season. More than one-fifth of the

[7] Cooperating with the Maine Agricultural Experiment Station in this study were the Maine Employment Service, the Maine Agricultural Extension Service, the Maine State Department of Agriculture, and the Bureau of Agricultural Economics of the United States Department of Agriculture.

potato pickers were less than 14 years of age, and nearly one-half of them were less than 18 years of age. Women and girls comprised more than one-third of the number of potato pickers. The average of 700 barrels of potatoes per picker during the harvest season in 1941 is probably as high as can be expected in the future years of the present emergency because (1) the harvest season is not likely to be longer, (2) more women and children are likely to take the place of men leaving to go to other civilian occupations and to the armed services. Workers having the physical ability and the skill to handle barrels and potato harvest-harvest machinery (comprising 35 per cent of the harvest-labor force in 1941) will be especially difficult to obtain. A report of this study in detail has been published as Maine Agricultural Experiment Station Miscellaneous Publication No. 568 under the title, "Potato-Harvest Labor in Aroostook County, Maine, 1941." A copy of this publication may be had upon request.

FIG. 8. Unloading potatoes at track storage.

MARKETING MAINE POTATOES

The efficient marketing of the potato crop is of vital importance to the entire industry. Due to the many problems in the marketing

of potatoes and to the many interests associated with the industry, the situation has often been confused and many varied suggestions have been offered for improvement.

Potato growers for many years have been alert to the use of new equipment and machinery, to the latest cultural methods, to new varieties, and in general to the lowering of the costs of producing potatoes per barrel. Too often growers have considered their work practically completed with the production of the crop. Marketing was only incidental and involved merely the disposal of the potatoes grown. It is imperative to consider that the problems of an enterprise like potatoes consist not only of producing the crop at the lowest possible cost but to market it by the most efficient marketing methods. It is only by both efficient production and efficient marketing methods that growers can hope to obtain the best returns from their labor and capital investments. While many farmers may not expect or hope to enter the field of marketing potatoes, they should maintain a continuous interest in the many aspects of the marketing processes. It should be recognized that there is a close relationship and often an over-lapping of production and marketing problems confronting the industry. The marketing problems for potatoes really begin in the production of the crop and end with the potatoes on the consumer's table.

Information on the practices of shippers and the costs of some of the more important operations was obtained by Charles H. Merchant[8] for the 1940-41 marketing season.

Since this study was undertaken, war has been declared on the United States by Germany, Italy, and Japan. In conducting this Second World War to a victorious end, many changes will be made in our way of living. Some of these changes will affect the marketing of the potato crop. Already rigid restrictions have been placed on burlap for new bags and on automobile tires. Other changes

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[8] This study has been made possible through the cooperative effort of the Maine Agricultural Experiment Station and the Potato Industry Tax. The author wishes to express his sincere appreciation for the splendid cooperation of potato growers and shippers; to Charles M. White, State Department of Agriculture, Augusta, Maine; to Mrs. Simonds, Bureau of Taxation, Augusta, Maine; and to many others who have furnished information for the study. The author was assisted in the field by Bertrand E. Blanchard, Walter E. Hanley, Donald M. Kilpatrick, and Keith M. Thompson.

during the war period will affect the industry and the marketing of the crop.

The suggestions for the improvement of marketing potatoes will be grouped under four general headings: (1) standardization of product, (2) cutthroat competition, (3) dealer service and publicity, and (4) research work.

Standardization of Product. One of the outstanding marketing problems facing the potato industry is that of standardization of its product. It is recognized that it is desirable to have several different qualities of potatoes to meet various consumer demands. Also, it is not practical to standardize each potato quality to the same extent as manufactured foods. However, the average consumer desires more uniformity among the potatoes of the same package and more uniformity between packages of the same lot of potatoes. This would involve more careful grading and sizing of potatoes, especially those going into consumer packages. While this would probably involve an additional cost to the shippers, the industry would probably benefit from it through improved reputation and increased demand for Maine potatoes. The potato industry may find it advantageous to establish the better grades somewhat superior to the Federal specifications.

The inspection service is a very important phase in the standardization of potato qualities. At present approximately 50 per cent of the potato shipments are inspected at shipping points. This service has greatly aided in the standardization of potato quality and more general use of the service should be considered by growers and shippers.

In the consideration of standardization, attention should be given to potato varieties. Many growers and shippers think in terms of the Green Mountain variety as a standard of quality. However, it is apparently becoming more and more difficult for many growers to produce this variety free from net necrosis and stem-end browning. Although new improved varieties are desirable, they should not be introduced on the market until sufficient time has elapsed for their qualities to be known.

In the plan for standardization of quality attention should be given to both nearby and distant markets. Local markets or other markets should not be the dumping ground for inferior potatoes unless these markets demand such quality.

Under normal conditions it would have been desirable for potato shippers to consider the advisability of shipping a larger percentage of their potatoes in consumer packages. Such packages, if standardized, would represent a real advertising feature for the industry. However, under the present emergency conditions it may be necessary to forego temporarily such a consideration.

Cutthroat Competition. Our economic way of living is based quite largely upon competition. However, it is recognized that united action is needed in the solution of many problems. Too little competition is undesirable as it often leads to uncontrolled monopolistic practices while too much competition is equally undesirable as it leads to sharp practices and duplicated efforts which are costly. Many industries have experienced in one way or another either too much or too little competition. Usually when there is too much competition there is a tendency for some individuals to be eliminated or some concerted action is taken by the most of the individuals. There seems to be too much competition among potato growers in many producing areas and too little competition in a few areas for the best interest of the industry.

Many shippers are forced by the keen competition to pursue policies which appear expedient for the present but lack foresight as to the future of the potato industry. This is a natural situation and perhaps shippers should not be criticized too severely. However, the present system of marketing is very costly due to duplicated effort on the part of shippers. But what is perhaps more important, the present sytsem does not lend itself readily to the development of markets for Maine potatoes. Further, attempts to reduce the costly duplicated services may come from growers and shippers in Maine or from interests in the terminal markets. This is an important question for growers and shippers to consider.

With many competing shippers, the difficulty of marketing a standardized product is greatly increased. Also, such problems as the transportation of potatoes, market containers, inspection service, and others do not receive the attention and concerted effort they rightly deserve.

Dealer Service and Publicity. While the scope of this study did not include any phase of dealer service work or the publicity of Maine potatoes, it is recognized that they have a place in a coordinated program for the potato industry. It seems logical that Maine growers and shippers should first standardize their products

in order to effect the best tangible results through dealer service and publicity work.

Dealer service men are in a position to inform growers and shippers of various market conditions and to acquaint men in the markets with growers' and shippers' problems. These men are not only ambassadors of good will but are in a position to offer ideas and suggestions for the improvement of market conditions which may be put into effect by potato shippers in production areas and by various dealers in the markets.

Research Work. No industry can develop faster than its leaders and these leaders need information and authentic facts to aid them in their thinking and in their actions. The entire industry, from the smallest grower to the largest shipper, should take an active interest in the problems of both production and marketing. In fact, the most satisfactory returns from potato production will depend on a well balanced and coordinated program of production and marketing. Each of these is dependent upon the other for maximum efficiency.

What effect or what changes the Second World War may bring to the potato industry is beyond the comprehension of any of us. However, it is impractical to delay our fact finding until the war is won. Rather, it would appear practical to render such aid as is possible during the emergency and make preparations for the post-war period. If this is logical thinking, the industry needs continuous research on its important problems. Along production lines, investigational work is needed on the production of improved varie ties, on cooking and the nutritional value of potatoes, better control methods for net necrosis and other diseases, on increased work on soil conservation, on farm management problems resulting from the emergency, and on many other problems of a production nature.

In marketing, information is needed on such problems as the probable availability of containers in which to ship potatoes to market during the emergency, transportation problems especially rail shipments (possible car shortage and delays in transit), consumer preferences for potatoes and other commodities during the emergency, on agricultural credit and prices, on grading and sizing of potatoes, and many other marketing problems. During the duration of the Second World War many new problems are likely to arise and our research groups should have as much information as possible to aid the industry.

The results of the study on which the foregoing conclusions are based were published in Miscellaneous Publication No. 569 of the Station, a copy of which may be had upon request.

PUBLICATIONS

Following is a list of publications giving the results of research on various phases of the potato industry. Any of these may be had upon request.

Comparison of Apparently Healthy Strains and Tuber Lines of Potatoes. Me. Agr. Exp. Sta. Bul. No. 358.

Isolated Tuber-Unit Seed Plots for the Control of Potato Virus Diseases and Blackleg in Northern Maine. Me. Agr. Exp. Sta. Bul. No. 370.

A Study of the Organization and Management of Potato Farms in Aroostook County, Maine. Me. Agr. Exp. Sta. Bul. No. 378.

A Study of the Organization and Management of Potato Farms in Central Maine. Me. Agr. Exp. Sta. Bul. No. 379.

Costs and Returns in Producing Potatoes in Aroostook County, Maine. Me. Agr. Exp. Sta. Bul. No. 390.

Costs and Returns in Producing Potatoes in Central Maine. Me. Agr. Exp. Sta. Bul. No. 392.

Bacterial Wilt and Soft Rot of the Potato in Maine. Me. Agr. Exp. Sta. Bul. No. 396.

Aphids and Their Relation to the Field Transmission of Potato Virus Diseases in Northeastern Maine. Me. Agr. Exp. Sta. Bul. No. 403.

Farm Organization and Costs and Returns in Producing Potatoes on Farms in the St. John River Area of Aroostook County, Maine, 1937. Me. Agr. Exp. Sta. Bul. No. 406.

Results of Testing Some Laboratory Methods for Possible Use in the Detection of Virus Diseases in Potato Tubers. Me. Agr. Exp. Sta. Bul. No. 407.

Potato Virus Disease Studies with Tuber-Line Seed Plots and Insects in Maine 1927 to 1938. Me. Agr. Exp. Sta. Bul. No. 410.

Marketing Maine Potatoes. 1. A Preliminary Report of Consumer Preference for Potatoes in Boston, March 4 to April 6, 1940. Me. Agr. Exp. Sta. Misc. Publ. No. 561.

Marketing Maine Potatoes. A Preliminary Report on Interregional Competition of Maine Potatoes on the Boston Market. Me. Agr. Exp. Sta. Misc. Publ. No. 563.

A Preliminary Report on Selling and Shipping Maine Potatoes. Me. Agr. Exp. Sta. Misc. Publ. No. 569.

Marketing Maine Potatoes. Retail Distribution of Potatoes in the Boston Metropolitan Area, March, 1940. F. C. A. Misc. Report No. 26.

Marketing Maine Potatoes. Purchase and Use of Potatoes and Substitutes in Homes of Boston Consumers, March 4 to April 6, 1940. F. C. A. Misc. Report No. 27.

Marketing Maine Potatoes. Organization and Market Practices in Maine and Boston. F. C. A. Misc. Report No. 31.

Marketing Maine Potatoes. Boston Retail Prices as Associated with Types of Packages, Retailers, and Consumer Incomes, February 26 to April 6, 1940. F. C. A. Misc. Report No. 36.

APPENDIX

TABLE 1

Ring Rot in Plants Developing from Diseased Tubers which Survived in the Field During Winter of 1940-1941

Field No.	Protection[1]	Number of tubers planted	Number of plants produced	Tubers whose plants developed ring rot[2]
				Per cent
1	Protected	100	65	45
	Not protected	100	71	51
2	Protected	200	149	51
	Not protected	200	135	46
3	Protected	100	82	42
	Not protected	100	80	57
4	Protected	200	150	52
	Not protected	200	147	53

[1] All tubers were placed in a trench six inches below the soil surface and covered with soil to the surface level. Part of each lot was further covered with 2 inches of weeds to serve as partial protection against cold.

[2] Per cent based on number of diseased tubers that were planted, not on plants produced.

TABLE 2

A Summary of the Number of Lots of Seed by Variety Entered in the 1941-1942 Florida Test and the Number of Lots Recommended for Planting as Certified Seed and Table Stock in 1941

Variety	Number of lots tested	Recommended for table stock seed[1]	Recommended for certified seed[2]
Bliss Triumph	7	3	2
Chippewa	33	16	10
Earlaine #2	1	0	1
Green Mountain	129	60	49
Houma	31	2	29
Irish Cobbler	77	30	36
Katahdin	71	7	60
Pontiac	1	0	1
Sebago	44	13	29
Warba	2	2	0

[1] Not more than 10 per cent leafroll.

[2] Disease not exceeding 2 per cent in leafroll and 3 per cent in mosaic.

TABLE 3

Summary of Acreage Represented by Samples Entered in 1941-1942 Florida Test and Acreage Represented by Samples Having Indicated Disease Readings

Variety	Acreage of each variety entered	Recommended for certified seed[1]	Recommended for table stock seed[2]
Bliss Triumph	78.0	18.0	51.5
Chippewa	484.8	84.5	209.3
Earlaine #2	4.4	4.4	0
Green Mountain	2008.6	717.7	932.0
Houma	136.0	122.5	13.5
Irish Cobbler	1260.9	551.8	592.5
Katahdin	762.5	631.0	132.5
Pontiac	1.0	1.0	0
Sebago	274.3	171.0	100.0
Warba	12.0	0	12.0

[1] Disease not exceeding 2 per cent in leafroll and 3 per cent in mosaic.
[2] Not more than 10 per cent leafroll.

TABLE 4

Aphid Species Collected on Crop Plants in Aroostook County, Maine—1941

Common name of insect	Scientific name	Total number of adults obtained in all collections from			
		Potatoes	Clover	Peas	Young clover[1]
The buckthorn aphid	Aphis abbreviata Patch	99	11	0	6
The green peach aphid	Myzus persicae (Sulz.)	127	12	0	23
The potato aphid	Macrosiphum solanifolii (Ashm.)	96	14	0	15
The foxglove aphid	Myzus pseudosolani Theob.	7	0	0	0
The pea aphid	Macrosiphum pisi (Kltb.)	0	450	334	42
Miscellaneous		0	38	0	8

[1] Young clover in fields from which peas were harvested.

TABLE 5

Stem-End Browning and Net Necrosis as Affected by Harvest Dates

Location	Storage temp.	8/11/42	8/26/42	9/8/42	9/24/42	10/8/42	10/22/42
		Per cent Stem-End Browning at different harvests					
Farm 1	36°F.	0	.93	1.44	3.02	1.44	3.73
	52°F.	7.46	9.80	9.84	11.96	18.73	15.13
		Per cent Net Necrosis at different harvests					
Farm 1	36°F.	0	.93	1.76	1.90	1.76	5.42
	52°F.	2.69	9.24	11.58	6.66	11.88	8.52
		Per cent Stem-End Browning at different harvests					
Farm 2	36°F.	1.76	1.13	1.68	4.09	3.38	6.45
	52°F.	6.41	18.46	23.00	14.89	13.33	18.23
		Per cent Net Necrosis at different harvests					
Farm 2	36°F.	2.35	11.32	11.40	26.36	31.71	33.54
	52°F.	20.26	37.69	39.80	48.08	55.69	45.68

TABLE 6

Mean Stem-End Browning and Net Necrosis Percentages in Samples from Four Fields in Seven Bins[1]

Bin	1	2	3	4	5	5	6	12
Temperature °F.	33	37	40	44	47	47	51	60
Series	A	A	A	B	A	B	B	B
Mean Net Necrosis Per Cent								
Field I	12	17	24	29	33	32	32	26
Field II	0.1	0.1	0.4	0.2	0.5	0.2	0.5	0.5
Field III	10	17	25	20	28[2]	20[2]	21	19
Field IV	13	15	23	32	31	34	37	33
Mean Stem-End Browning Per Cent[3]								
Field I	6	5	6	7	8	7	9	13
Field II	10	11	15	18	29	26	33	47
Field III	3	3	2	2	3	3	8	9
Field IV	3	3	4	5	5	4	8	9

[1] Each mean represents 4 to 6 samples, usually 6.

[2] In III, series A was dug from part of the field closer to a Katahdin field than series B. Possibly more leafroll came into A than into B from the Katahdin field.

[3] In fields I, III, and IV, masked in part by net necrosis, according to Goven.

TABLE 7

Relationship of Maximum Net Necrosis Per cent to Leafroll Per cent Spread in 1941

Field	Series	Leafroll per cent				Net necrosis per cent (and number of samples)		Leafroll per cent 1941-42 showing as net necrosis[3]		Leafroll per cent 1941 spread showing as net necrosis[4]	
		1941 from seed[1]	1941-42[2] Green-house	1941-42[2] Flor-ida	1941 spread	Bin 5	Bin 6	Bin 5	Bin 6	Bin 5	Bin 6
I	A	5	42		37	41(3)		98		111	
	B					40(3)	40(3)	95	95	108	108
II	A	0.1		0.8	0.7	0.6(5)		75		88	
	B					0.6(2)	0.6(4)	75	75	88	88
III	A	7	36		29	28(6)		78		97	
	B					21(5)	24(2)	58	67	72	83
IV	A	7	48		41	31(6)		65		76	
	B					32(5)	37(6)	67	77	78	90

[1] Estimates by Upton from memory 4/15/42.
[2] One sample from each field; this sample is used here for comparison in each series.
[3] Average I 96
II 75
III 68
IV 70
[4] Average I 109 (probably greenhouse sample was too small to give representative reading.)
II 88
III 84
IV 81

TABLE 8

Net Necrosis and Stem-End Browning on Organic Plots—1941

Previous crop and treatment[1]	Pounds per acre 8-16-20 on potatoes	Net necrosis Per cent	Stem-End Browning Per cent
Potatoes	1,000	1,000	10.7	7.6
Potatoes	1,500	1,500	24.7	9.4
Crimson	0	1,000	20.6	6.2
Corn	0	1,000	8.8	3.2
Crimson	0	1,500	17.6	13.9
Corn	0	1,500	19.1	5.2
Crimson	250	750	11.6	4.1
Corn	250	750	2.8	4.7
Crimson	500	1,000	9.9	6.5
Corn	500	1,000	15.3	4.0
Average of all crimson plots			14.8	7.1
Average of all corn plots			11.6	4.4

[1] Figure indicates pounds per acre of fertilizer used.

TABLE 9

Stem-End Browning and Net Necrosis in Potatoes from the Permanent Plots—1941

Treatment	Average % N.N.	Average % S.E.B.
Check Plots		
2,000 lbs. of 4-8-8 (N. half)	8.0	12.0
2,000 lbs. of 4-8-8	9.7	21.4
Rate of Application		
No fertilizer	1.6	1.6
1,500 lbs.	4.5	9.6
2,000 lbs.	9.7	21.4
2,500 lbs. (on Knoll)	13.6	24.8
3,000 lbs.	17.7	29.8
Fertilizer Ratios		
0-8-8	5.8	12.7
2-8-8	6.7	12.9
4-8-8	9.7	21.4
6-8-8	11.7	13.0
4-0-8	13.5	12.3
4-4-8	6.5	11.7
4-8-8	9.7	21.4
4-12-8	10.9	16.5
4-8-0	.8	.5
4-8-4	6.2	3.6
4-8-8	9.7	21.4
4-8-10	8.0	20.9
4-8-12	11.6	48.2
Sources of Nitrogen		
Nitrate of soda	6.8	15.7
Sulfate of ammonia	12.0	14.6
Urea	7.9	12.1
Fish meal	12.6	14.5
Cyanamid	9.8	12.6
½-½-0	11.0	13.2
⅜-⅜-¼	9.7	21.4
¼-¼-½	7.6	12.8
Chemically Pure Salts		
Plot 1	1.6	1.8
" 2	4.1	2.7
" 3	2.8	3.6
" 4	3.5	3.4
" 5	5.2	2.6
" 6 (on Knoll)	2.3	1.1
" 7	3.7	2.5
Acid versus Neutral Fertilizers		
Acid mixture	7.1	12.3
Acid mixture plus kieserite	11.0	10.3
Acid mixture plus dolomite	8.9	15.1
Acid mixture plus calcium limestone	8.2	11.4
Potassium Sulfate versus Potassium Chloride		
K_2SO_4 Unlimed N. ½ plot	2.6	4.7
K_2SO_4 Limed ½ plot	4.6	4.8
KCl Unlimed N. ½ plot	8.0	12.0
KCl Limed ½ plot	8.1	23.6
Check Plots		
2,000 lbs. of 4-8-8	12.0	14.9
2,000 lbs. of 4-8-8	19.2	19.0

TABLE 9—(Continued)

Treatment	Average	
	% N.N.	% S.E.B.
Effect of Organic Matter		
Check, crimson removed	9.3	13.7
Check	19.2	19.0
Check, plus crimson from plot 427	17.7	15.3
Check, plus straw (6 tons per acre)	11.4	19.4
Check, plus manure (20 tons per acre)	14.8	24.3
Sources of Nitrogen		
Nitrate of soda	12.2	15.6
Sulfate of ammonia		
(unlimed N. ½ of plot)	13.3	7.3
(limed ½ of plot)	11.3	17.4
Ammonium chloride		
(unlimed N. ½ of plot)	25.7	20.2
(limed ½ of plot)	29.7	31.3
½ nitrate of soda, ½ sulfate of ammonia	7.3	17.3
Delayed nitrogen	6.4	14.0
Broadcast Application of P_2O_5 and K_2O		
A—4-8-8 (½-½-0) 2,000 lbs. per acre	4.4	9.0
B—4-8-8 plus Ca hydrate	11.9	18.5
C—4-8-8 plus MgO 2,000 lbs. Sea Water MgO	11.7	14.5
D—4-8-8 Dol. L.S. 2,000 lbs. per acre	3.2	7.6
(D = D.L.S. containing 670 lbs. CaO (B received), and 380 lbs. MgO (C received).)		
Continuous Cropping to Potatoes		
Check, plus peat (1936-1940 total 40 tons)	3.9	8.5
Check	4.1	21.4
4-8-10	4.1	25.3
2,500 lbs. of 4-8-8	7.9	20.6
Check plus 20 tons manure	27.6	23.1
Total of all plots	8.00	12.83

TABLE 10

Net Necrosis and Stem-End Browning on Potash Source and Ratio Test—1941

Treatment	Farm A		Farm B	
	% N.N.	% S.E.B.	% N.N.	% S.E.B.
4-8-8 KCl	1.9	42.0	18.1	11.1
4-8-10 KCl	1.1	38.5	20.5	6.9
4-8-12 KCl	.7	33.2	19.1	6.9
4-8-16 KCl	2.2	31.8	26.2	7.2
4-8-8 K_2SO_4	3.1	19.3	14.8	5.3
4-8-10 K_2SO_4	1.0	30.5	16.5	5.1
4-8-12 K_2SO_4	1.5	28.9	8.2	6.9
4-8-16 K_2SO_4	.5	14.4	12.1	4.8
4-8-8 ⅓ from each salt (KNO3, KCl, K_2SO_4)	2.8	6.4	12.2	7.1
4-8-10 ⅓ from each salt (KNO3, KCl, K_2SO_4)	1.3	11.7	19.0	3.6
4-8-12 ⅓ from each salt (KNO3, KCl, K_2SO_4)	0	26.5	18.6	6.3
4-8-16 ⅓ from each salt (KNO3, KCl, K_2SO_4)	.9	48.9	19.1	11.3
4-8-10 ½ KCl, ½ K_2SO_4	1.4	13.7	18.9	7.7
4-8-10 ½ KCl, ½ KNO_3	.4	42.2	14.5	9.8
4-8-10 ½ K_2SO_4, ½ KNO_3	1.8	26.8	5.8	8.1
Average for farm	1.4	26.8	16.0	7.3

TABLE 11

Net Necrosis Percentages in Samples from Field IV

Days after digging	Net necrosis percentages in different samples[1]							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
3[2]	10	10	10	10	10	10	10	10
43	13	15	21	27	34	—	—	—
44	—	—	—	—	—	31	38	36
52	13	—	—	—	—	—	—	—
53	—	15	20	31	30	35[4]	—	—
57	—	—	—	—	—	—	37	35
70	12	—	—	—	—	—	—	—
71	—	13	22	—	30	—	—	—
72	—	—	—	35	—	32	—	—
74	—	—	—	—	—	—	37	32
100	12	—	—	—	—	—	—	—
101	—	14	23	—	—	—	—	—
102	—	—	—	34	30	33	—	—
105	—	—	—	—	—	—	35	34
127	12	—	—	—	—	—	—	—
128	—	15	25	—	—	—	—	—
129	—	—	—	33	31	—	—	—
130	—	—	—	—	—	35	—	—
133	—	—	—	—	—	—	37	—
134	—	—	—	—	—	—	—	30
154	15	—	—	—	—	—	—	—
155	—	15[3]	24	32	29	35	36	—
156	—	—	—	—	—	—	—	30
Total	77	87	135	192	184	201	220	197
Mean	13	15	23	32	31	34	37	33

[1] The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.
[2] Samples examined at beginning of storage period. Excluded from total below.
[3] Maximum (15.4%) for bin 2.
[4] Maximum (35.2%) for bin 5, series B.

TABLE 12

Net Necrosis Percentages in Samples from Field I

Days after digging	Net necrosis percentages in different samples[1]							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
2[2]	7	7	7	—	7	—	—	—
5[2]	—	—	—	6	—	6	6	6
19	—	—	—	—	—	—	15	—
21	5	5	12	—	—	—	—	—
22	—	—	—	18	16	16	—	16
30	7	10	—	—	—	—	—	—
31	—	—	13	22	29	—	—	—
32	—	—	—	—	—	28	24	—
33	—	—	—	—	—	—	—	27
43	10	—	—	—	—	—	—	—
45	—	12	—	—	—	—	—	—
46	—	—	19	28	29	27	—	—
51	—	—	—	—	—	—	32	30
63	—	25	—	—	—	—	—	—
64	14	—	—	—	—	—	—	—
65	—	—	30	33	40	41	—	—
66	—	—	—	—	—	—	39	31
91	17	—	—	—	—	—	—	—
92	—	24	33	—	42	—	—	—
93	—	—	—	35	—	40	—	—
96	—	—	—	—	—	—	40	—
120	18	—	—	—	—	—	—	—
121	—	26	—	—	—	—	—	—
122	—	—	34	36	41	—	—	—
126	—	—	—	—	—	40	—	—
127	—	—	—	—	—	—	41	—
Total	71	102	141	172	197	192	191	104
Mean	12	17	24	29	33	32	32	26

[1] The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.

[2] Samples examined at beginning of storage period. Excluded from total below.

TABLE 13

Net Necrosis and Stem-End Browning Percentages in Samples from Field II, Mostly Shifted from Low to Moderately High Temperature During Storage

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	205	34	63	—	—	34	63	0	11	30 days at 34° reduced S.E.B. development at 50° later
A	214	34	30	50	34	43	64	0.5	14	
A	212	34	20	51	44	46	64	0.3	28	
A	210	34	10	51	54	48	64	0.2	26	
A	206	33	90	—	—	33	90	0.4	12	
A	215	35	30	52	61	46	91	0.7	21	
A	213	34	20	52	71	48	91	0.5	28	
A	207	33	120	—	—	33	120	0.2	13	90 days at 34° inhibited S.E.B. development at 52° later, and 60 days at 34° greatly reduced it
A	218	34	90	52	31	39	121	0	13	
A	217	34	60	52	60	43	120	0.2	14	
A	216	34	30	52	90	48	120	0.4	23	
A	218	34	90	52	31	39	121	0	13	31-35 days at 50-52° induced more S.E.B. after 10 days at 34° than after 30-90 days at 34°
A	214	34	30	50	34	43	64	0.5	14	
A	209	34	10	50	35	46	45	0.6	17	
A	217	34	60	52	60	43	120	0.2	14	45-61 days at 46-52° induced less S.E.B. as previous storage at 34-35° was longer
A	215	35	30	52	61	46	91	0.7	21	
A	210	34	10	51	54	48	64	0.2	26	
B	246	—	—	46	45	46	45	0	30	

TABLE 14

Net Necrosis and Stem-End Browning Percentages in Samples from Field III, Mostly Shifted from Low to Moderately High Temperature During Storage

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	313	35	50	47	20	38	70	12	2	After 50 days at 35°, the longer the storage at 47° the more N.N. % developed
A	314	35	50	47	22	39	72	14	2	
A	315	35	50	47	30	40	80	16	3	
A	316	35	50	48	41	41	91	19	2	
A	317	35	50	47	50	41	100	21	4	
A	333	—	—	47	73	47	73	27	3	
A	305	33	100	—	—	33	100	11	4	The higher the mean temp. during 100 days storage, the more N.N. % developed
A	318	34	75	47	25	37	100	16	3	
A	317	35	50	47	50	41	100	21	4	
A	334	—	—	47	101	47	101	26	5	
A	308	34	25	46	17	39	42	19	1	17-25 days at 46-47° induced less N.N. % after 50-75 days at 34-35° than after 25 days at 34°
A	309	34	25	46	24	40	49	21	3	
A	313	35	50	47	20	38	70	12	2	
A	314	35	50	47	22	39	72	14	2	
A	318	34	75	47	25	37	100	16	3	
A	305	33	100	—	—	33	100	11	4	

TABLE 15

Net Necrosis and Stem-End Browning Percentages in Samples from Field I, Mostly Shifted from Moderately High to Low Temperature During Storage

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
B	146	47	46	—	—	47	46	27	9	Net necrosis percentage is increased by higher mean temperature
A	133	47	46	—	—	47	46	29	9	
B	153	47	20	35	31	40	51	27	6	
B	151	47	10	35	41	37	51	20	7	
A	104	—	—	35	43	35	43	10	6	
B	147	47	65	—	—	47	65	41	6	Do
A	134	47	65	—	—	47	65	40	6	
B	156	47	30	35	36	40	66	30	7	
B	154	47	20	34	46	38	66	31	4	
B	152	47	10	34	55	36	65	21	4	
A	105	—	—	34	64	34	64	14	7	
B	148	47	93	—	—	47	93	40	7	Do
A	135	47	92	—	—	47	92	42	8	
B	157	47	30	34	65	38	95	34	8	
B	155	47	20	34	75	37	95	31	5	
A	106	—	—	33	91	33	91	17	6	
B	149	47	126	—	—	47	126	40	8	Do
A	136	47	122	—	—	47	122	41	10	
B	160	47	90	32	37	43	127	39	10	
B	159	46	60	33	66	39	126	35	10	
B	158	47	30	33	96	36	126	34	7	
A	107	—	—	33	120	33	120	18	6	

TABLE 16

Net Necrosis and Stem-End Browning Percentages in Samples from Field II, Mostly Shifted from Moderately High to Low Temperature During Storage

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
B	246	46	45	—	—	46	45	0	30	Stem-end browning percentage is increased by higher mean temperature
B	253	47	20	38	28	42	48	0	14	
B	251	47	10	38	38	40	48	0.2	15	
A	204	—	—	35	45	35	45	0	9	
B	247	47	66	0	0	47	66	0	30	Do
B	256	47	30	38	36	42	66	0.2	17	
B	254	47	20	38	46	41	66	0.3	14	
B	252	47	10	38	56	39	66	0.2	14	
A	205	—	—	34	63	34	63	0	11	
B	248	47	94	—	—	47	94	0.9	33	Do
B	257	47	30	37	65	40	95	0.3	17	
B	255	47	20	37	74	39	94	0	13	
A	206	—	—	33	90	33	90	0.4	12	
B	249	47	122	—	—	47	122	0.3	33	Do
B	260	47	90	36	33	44	123	0.5	30	
B	259	47	60	36	63	41	123	0.2	29	
B	258	47	30	36	93	39	123	0.5	19	
A	207	—	—	33	120	33	120	0.2	13	

TABLE 17

Percentage of Net Necrosis, Stem-End Browning, and Total Tubers with 10 Per cent Waste Due to Net Necrosis and Stem-End Browning, by Number and by Weight

Sample	Tubers by number					Tubers by weight				
	Total No.	Net Necrosis		Stem-End Browning		Total Lbs.	Net Necrosis		Stem-End Browning	
		Total %	Cull[1] %	Total %	Cull[1] %		Total %	Cull[1] %	Total %	Cull[1] %
465 (Bin 6)	620	37.3	37.3 (all of the NN)	9.8	3.9 (26.4% of the SEB)					
471 (Bin 12)	580	30.0	29.1 (97.1% of the NN)	10.5	4.7 (44.3% of the SEB)	140	35.5	34.1 (96.0% of the NN)	9.9	4.6 (47.1% of the SEB)
371 (Bin 12)	380	19.7	19.7 (all of the NN)	13.2	4.5 (34.0% of the SEB)					
PP403[2] (Bin 11, 40-42")	180	8.9		16.7		49.5	10.6		19.2	5.1 (26.3% of the SEB)

[1] Cull means tubers each of which lost 10 per cent or more by weight when all internally discolored tissue was removed.
[2] Permanent Plot sample.

TABLE 18

Effect of B, Cu, Fu, and Zn in Fertilizer on Stem-End Browning and Net Necrosis—1941

Treatment	Stem-End Browning			Net Necrosis		
	Unlimed	Limed[1]	Average	Unlimed	Limed[1]	Average
Regular 8-16-16	18.0	15.2	16.6	15.9	19.0	17.4
Regular + 10# Borax	10.8	11.2	11.0	14.8	14.5	14.6
Regular + 10# $CuCl_2$	17.2	23.5	20.4	10.5	11.1	10.8
Regular + 50# $CuCl_2$	11.9	14.8	13.4	11.3	11.7	11.5
Regular + 100# $CuCl_2$[2]	13.3	10.1	11.7	10.7	7.7	9.2
Regular 50# CaF_2	18.2	20.5	19.4	14.0	11.9	13.0
Regular 25# $ZnSO_4$	10.6	18.1	14.4	23.1	19.6	21.4
4-8-4 50# $CuSO_4$	6.6	10.7	8.6	12.8	15.3	14.0
4-8-16 50# $CuSO_4$	10.1	14.8	12.4	10.1	12.0	11.0

[1] Limed at rate of 1,000 pounds hydrated dolomite per acre.
[2] Planted 6 days later on June 18, 1941.

TABLE 19

Net Necrosis and Stem-End Browning on Tuber Samples from Commercial Farms—1941

Farm No.	Location	Fertilizer	N.N. %	S..E.B. %	Soil Analysis										
					pH	O.M.	NO_3	NH_3	P	K	Ca	Mg	Mn	Fe	Al
1	Presque Isle	1,000 10-16-24	22.9	5.5	5.50	*5.17*	60	400–	100	Ex	1,000	25	25	10	100+
2	Presque Isle	1,200 8-16-14	20.4	8.0	5.49	*7.26*	60	400–	25	Ex	2,000	10	25	10	100+
3	Presque Isle	1,100 8-16-14	24.9	10.1											
4	Caribou	2,300 5-8-10	.4	16.0	5.08	*4.74*	60	400	100	Ex	750	10	10	10+	100+
5	Presque Isle	1,000 8-16-16 K_2SO_4	5.7	20.0											
6	Presque Isle	2,000 4-8-8 KCl	5.4	28.0											
7	Presque Isle	1,000 8-16-20	8.5	35.4											
8	Mapleton	1,250 8-16-20	.5	39.1	6.05	*6.03*	40	400–	50	Ex	2,000–	25+	10	10–	100
9	Caribou	2,000 5-8-12	.2	46.6	5.73	*4.80*	40	400–	100	Ex	1,000	10	5+	10	100+
10	Presque Isle	1,200 8-16-14	1.1	48.6	6.11	*5.04*	100	400+	200	Ex	3,000	50	25	5	100–
11	Presque Isle	1,200 8-16-14	2.0	52.1	5.62	*5.35*	100	400–	25+	Ex	1,500	10	10	10	100
12	Presque Isle	Potash test	16.0	7.3	5.60	*4.74*	40–	400–	100	300+	1,000+	25+	10	10–	100
13	Presque Isle		6.7	12.0	5.58	*6.03*	10–	400–	25+	300+	1,500	25	5	10+	100
14	Caribou	Potash test	1.4	26.8											

TABLE 20

Net Necrosis and Stem-End Browning Percentages in Samples from Field I, Mostly Shifted from Low to Moderately High Temperature During Storage

Series	Sample	1st period		2nd period		Both periods		N.N. %	S.E.B. %	Conclusions
		Temp. °F.	Days	Temp. °F.	Days	Mean temp. °F.	Days			
A	103	34	30	—	—	34	30	7	6	10 days at 34° reduced
A	108	34	10	47	20	43	30	13	6	net necrosis development
A	132	—	—	47	31	47	31	29	7	at 47° later
B	145	—	—	47	32	47	32	28	7	
A	104	35	43	—	—	35	43	10	6	
A	111	34	20	46	24	41	44	13	9	
A	109	34	10	46	34	43	44	20	12	
A	133	—	—	47	46	47	46	29	9	
B	146	—	—	47	46	47	46	27	9	
A	105	34	64	—	—	34	64	14	7	20 to 30 days at 34°
A	114	34	30	47	34	41	64	15	6	reduced net necrosis
A	112	34	20	47	44	43	64	19	7	development at 47°
A	110	34	10	47	54	45	64	37	5	later
B	147	—	—	47	65	47	65	41	6	
A	106	33	91	—	—	33	91	17	6	20 days at 34° reduced
A	115	34	30	47	61	43	91	16	8	net necrosis development
A	113	34	20	47	71	44	91	23	6	at 47° later while 30
A	135	—	—	47	92	47	92	42	8	days inhibited it
B	148	—	—	47	93	47	93	40	7	
A	107	33	120	—	—	33	120	18	6	30 to 90 days at 34°
A	118	34	90	47	31	38	121	13	7	inhibited net necrosis
A	117	34	60	47	60	41	120	15	9	development at 47°
A	116	34	30	47	90	44	120	18	7	later
B	149	—	—	47	126	47	126	40	8	
A	118	34	90	47	31	38	121	13	7	31 to 34 days at 46-47°
A	114	34	30	47	34	41	64	15	6	induced less net necrosis
A	109	34	10	46	34	43	44	20	12	percentage according to
A	132	—	—	47	31	47	31	29	7	preceding length of storage at 34°
A	112	34	20	47	44	43	64	19	7	44-46 days at 47° induced
A	133	—	—	47	46	47	46	29	9	less net necrosis after 20 days at 34°
A	117	34	60	47	60	41	120	15	9	54-65 days at 47° induced
A	115	34	30	47	61	43	91	16	8	much less net necrosis
A	110	34	10	47	54	45	64	37	5	after 30-60 days at 34°
B	147	—	—	47	65	47	65	41	6	than after 0-10 days
A	116	34	30	47	90	44	120	18	7	90-92 days at 47° induced
A	135	—	—	47	92	47	92	42	8	much less net necrosis after
B	148	—	—	47	93	47	93	40	7	30 days at 34° than after none at 34°

TABLE 21

Stem-End Browning Percentages in Samples from Field II

Days after digging	Stem-End Browning Percentages in different samples[1]							
	1 33° A	2 37° A	3 40° A	4 44° B	5 47° A	5 47° B	6 51° B	12 60° B
6[2]	4	4	4	—	4	—	—	—
7[2]	—	—	—	5	—	5	5	5
17	7	10	—	—	—	—	—	—
18	—	—	10	—	—	—	—	—
20	—	—	—	12	10	—	—	—
21	—	—	—	—	—	10	10	28
27	6	—	—	—	—	—	—	—
29	—	12	14	—	—	—	—	—
30	—	—	—	14	—	22	—	—
32	—	—	—	—	27	—	—	—
34	—	—	—	—	—	—	33	50
45	9	9	11	16	29	30	—	—
48	—	—	—	—	—	—	33	—
49	—	—	—	—	—	—	—	53
63	11	—	—	—	—	—	—	—
64	—	11	—	—	—	—	—	—
65	—	—	13	20	33	—	—	—
66	—	—	—	—	—	30	39	48
90	12	—	—	—	—	—	—	—
91	—	12	—	—	—	—	—	—
92	—	—	14	—	37	—	—	—
94	—	—	—	22	—	33	—	—
95	—	—	—	—	—	—	43	—
97	—	—	—	—	—	—	—	48
120	13	—	—	—	—	—	—	—
121	—	13	25	—	—	—	—	—
122	—	—	—	22[3]	39	33[4]	—	—
125	—	—	—	—	—	—	42	52
Total	58	67	87	106	175	158	200	279
Mean	10	11	15	18	29	26	33	47

[1] The next 3 lines indicate respectively the bins (1 to 6 and 12), the mean temperatures in °F., and the series.
[2] Samples examined at beginning of storage period. Excluded from total below.
[3] Maximum (22.3%) for bin 4.
[4] Maximum (33.1%) for bin 5, series B.

TABLE 22

Yield for Houma Potato Plots Sprayed with Different Copper Spray Fungicides in 1941 with a Horse-Drawn, Wheel-Traction Outfit

Fungicide	Formula	Yield per acre[1]	
		Bushels	Barrels
Tribasic copper sulphate[2]	4 – 100	350± 8.7	127±3.2
Copper hydro arsenate[3]	5 – 100 and 0.5 pound soybean flour	365± 8.3	133±2.9
Copper hydro arsenate-ite[4]	Do	364±10.0	132±3.7
Spray-cop[5]	6 – 100	348± 8.7	127±3.1
General Chemical Company fungicide[6]	4 – 100	351± 6.2	128±2.1
Yellow cuprocide[7]	1 – 100	330±11.4	120±4.1
Bordeaux mixture control	10-5-100	353± 6.7	128±2.5

[1] Each yield rate is a mean from eight replicated plots each containing 240 feet of row. Significantly different from bordeaux rate in no case, but nearly so for yellow cuprocide.
[2] Said to contain 53 per cent metallic copper; manufactured by Tennessee Copper Co., Copperhill, Tenn.
[3] Said to contain approximately 17.97 per cent metallic copper and 10.59 per cent arsenic; manufactured by Chipman Chemical Co., Bound Brook, N. J.
[4] Said to contain approximately 18.18 per cent metallic copper and 10.71 per cent arsenic; manufactured by Chipman Chemical Co., Bound Brook, N. J.
[5] Said to contain 34 per cent metallic copper; manufactured by General Chemical Co., New York, N. Y.
[6] Said to contain 34 per cent metallic copper plus a sticking agent; manufactured by General Chemical Co., New York, N. Y.
[7] Said to contain 83 per cent metallic copper; manufactured by Röhm and Haas Co., Philadelphia, Pa.

TABLE 23

Yield Comparison of Green Mountain Plots Sprayed with Bordeaux Prepared with Different Formulae

Formula	Yield rate per acre[1]		Approximate odds in comparison with 10-5-100 formulae
	Barrels	Bushels	
10-10-100	160±2.8	440± 8.1	1.00 to 1
8-8-100	153±3.5	421± 9.8	1.00 to 1
8-4-100	162±3.9	445±10.9	1.39 to 1
10-5-100	156±3.2	428± 8.8	—
Check not sprayed	99±0.2	271± 0.5	Very high

[1] Each yield rate is a mean from eight replicated two-row plots each consisting of 270 feet of row.

TABLE 24

The Effect on Yield of Spraying Green Mountain Potatoes with Copper Fungicides and with Combinations of These Fungicides with Rotenone for 1941[1]

Fungicide	Formula	Yield per acre 1941 barrels[2] [3]		Increase from applying rotenone	
		Without rotenone	With rotenone	Barrels	%
Bordeaux mixture	10-10-100	169	181	12	7.1
Bordeaux mixture	10- 5-100	169	178	9	5.3
Basi-cop[4]	5-100	168	177	9	5.1
Spray-cop[5]	6-100	162	179	17	9.5
Yellow cuprocide[6]	1.5-100	167	178	11	6.6

[1] Data for a similar experiment in 1940 are presented in Bul. 465, page 483.
[2] Significance at 5 per cent level is 7.36 barrels.
[3] Each yield rate is a mean from 14 replicated plots, each plot consisting of 1,200 feet of row.
[4] Said to contain 52 per cent metallic copper; manufactured by Sherwin-Williams Co., Cleveland, O.
[5] Said to contain 34 per cent metallic copper; manufactured by General Chemical Co., New York, N. Y.
[6] Said to contain 83 per cent metallic copper; manufactured by Röhm and Haas Co., Philadelphia, Pa.

TABLE 25

Yields for Green Mountain Plots Receiving Dust or Bordeaux Fungicide with and without an Insecticide

Fungicide	Yield per acre[1] Barrels	Yield increase per acre in comparison with bordeaux[2] Barrels
Dust and oil[3]	168±1.21	9
Dust, oil, and insecticide[3]	175±1.96	16
Bordeaux (10-5-100)[4]	159±1.8	—
Bordeaux and rotenone[4]	173±1.3	14

[1] Each yield rate is from 10 replicated plots each containing 300 feet of row.
[2] Significance at the 5 per cent level is 5.43 barrels.
[3] The Vapo Dust machine is manufactured by the Root Duster Co. of Cleveland, O., and was supplied by courtesy of the California Spray Chemical Company, Elizabeth, N. J. Approximately 40 pounds of dust was applied per acre per application. The dust consisted of 6 per cent Red Copper Oxide and 94 per cent Bancroft Clay. Approximately 2 gallons of "Vaporal" mineral oil was applied per acre per application. The insecticide in the form of "Extrax" contained 2.5 per cent rotenone and 0.4 per cent pyrethrum and was added to the oil at the rate of one pint to two gallons of oil.
[4] Bordeaux was applied with a tractor power spray machine. Three pounds of four per cent rotenone in the form of ground derris root was mixed with 100 gallons of bordeaux just prior to making the application.

TABLE 26

Effect of Seed Spacing on Yield of Eight Potato Varieties—1941

Stillwater, Maine					Presque Isle, Maine				
Variety	Total yield		Per cent U.S. No. 1	U.S. No. 1	Variety	Total yield		Per cent U.S. No. 1	U.S. No. 1
	Bu.	Bbl.		Bu. Bbl.		Bu.	Bbl.		Bu. Bbl.
Six-inch spacing									
Earlaine #2	447	163	89	397 144	Earlaine #2	504	183	82	416 151
Chippewa	398	145	85	341 124	Warba	434	158	79	344 125
Houma	391	142	81	315 115	Kathadin	432	157	88	380 138
Sebago	369	134	84	309 112	Sebago	417	152	—	— —
Katahdin	357	130	86	307 112	Houma	406	148	73	295 107
Green Mountain	338	123	89	301 109	Chippewa	400	145	76	302 110
Irish Cobbler	288	105	78	224 81	Green Mountain	393	143	90	334 121
Warba	279	101	85	238 87	Irish Cobbler	371	135	60	249 91
Nine-inch spacing									
Earlaine #2	446	162	91	406 148	Earlaine #2	502	183	87	439 160
Chippewa	365	133	87	317 115	Sebago	419	152	82	346 126
Sebago	360	131	91	325 118	Chippewa	408	148	80	327 119
Katahdin	337	123	91	305 111	Katahdin	400	145	87	348 127
Houma	324	118	82	267 97	Irish Cobbler	394	143	76	301 109
Green Mountain	322	117	92	297 108	Houma	387	141	77	296 108
Irish Cobbler	305	111	84	257 93	Green Mountain	384	140	89	342 124
Warba	253	92	85	215 78	Warba	360	131	84	302 110
Twelve-inch spacing									
Earlaine #2	410	149	93	381 139	Earlaine #2	510	185	92	470 171
Sebago	336	122	92	311 113	Katahdin	397	144	89	352 128
Chippewa	329	120	91	298 108	Sebago	393	143	82	322 117
Katahdin	317	115	92	293 107	Warba	388	141	86	331 120
Houma	317	115	82	261 95	Chippewa	375	136	86	323 117
Green Mountain	289	105	93	269 98	Irish Cobbler	374	136	81	302 110
Irish Cobbler	272	99	89	241 88	Green Mountain	370	135	90	334 121
Warba	260	95	88	229 83	Houma	360	131	81	291 106

TABLE 27

1941 Yield Test—Starch Varieties Randomized with Five Replicates A to E

Variety	No. of potatoes to 5 kg.	Flesh color	Starch Ave. of 5 plots	Starch per acre basis primes and culls	Starch per 11 pk. bbl.[1]
				Lbs.	Lbs.
Parnasia	45	W	16.0	1,080	26.5
Matador	31	Y–W	17.3	2,760	28.7
Popular	71	Y	18.6	2,450	30.8
Record	42	Y	18.9	3,700	31.1
Fruhegold	49	Y	14.1	2,830	23.4
Ostbote	49	Y–W	20.4	4,700	33.5
Voran	45	Y–W	18.0	4,150	29.7
To be ident.	51	Y–W	18.6	4,200	30.8
Mittlefruhe	43	Y–W	17.5	3,900	28.9
Ackersegen	37	Y–W	17.0	4,460	28.1
Green Mountains	30	W	18.5	5,100	30.5
Katahdin	33	W	15.4	3,550	25.3
Houma	41	W	15.4	4,240	25.3

[1] Bushel to barrel factor 2.75.

DAIRYING RESEARCH

The dairy industry is Maine's second largest agricultural enterprise from the standpoint of cash income. It is expected that milk production in the State during 1942 will be slightly higher than in the previous year.[1] This has occurred in spite of decreases in some herds as a result of a disease eradication program, a hay shortage in the 1941 crop season, and an acute labor problem. Milk production per cow has been progressing upward and grain prices in general have been relatively favorable. Studies are in progress on the possibilities for continued improvement in the industry by means of improved pastures and roughage; by means of improving concentrates, at least for supplementing rations now being used; and by evaluating the economics of dairy farm organization, and milk production and marketing.

ECONOMICS OF THE DAIRY INDUSTRY

Studies on the business of farming have revealed wide variations in the net returns obtained by different farmers. There are, however, numerous factors which have a bearing on the net returns. Some of these are the efficiency of management, the land resources, the availability of markets, the manner of marketing, and price relationships. Data on these various items for many farms are helpful in drawing conclusions as to why certain farmers obtain higher net returns than do other farmers in the same area and with similar possibilities.

Dairy Farm Organization and Management. It was found by Emil Rauchenstein[2] and Andrew E. Watson that the farmer in central Maine who specialized in dairying and had no supplemental cash producing enterprise received on the average a normalized net income of only $230 for the year 1936. Among 214 farms studied in this area, the strictly dairy farm had the lowest normalized net income for that year. The farmer who had a supplemental income from potatoes, sweet corn, peas, poultry, or wood, had on

[1] "Factors Affecting Milk Production During 1942" and "Statistical Supplement" by Geo. F. Dow, Me. Agr. Exp. Sta., and Donald W. Reed, Me. Ext. Service. Mimeographed Report.

[2] U. S. Bureau of Agricultural Economics.

the average a net income of $874. It was found, also, that the farmer who followed approved soil conservation practices had an income which was better than the average of the farmers in this area.

Labor is an important item on the dairy farm, particularly now when labor is scarce. The use of milking machines was effective in reducing the amount of labor required by about 35 hours per cow annually. Only 15 per cent of the farms, however, possessed this equipment. High milk production per cow, also, is an important item in the efficient use of labor. The average labor requirement per cow for all classes was 191 hours per year. The cows with high milk production, however, required only 3.0 hours of man labor per 100 pounds of milk as compared with 4.9 hours for the low producers. A rapid decline in milk production per cow during the summer months after June suggests the need for supplementary improved pastures as a means for more economical milk production.

FIG. 1. Raising heifers for dairy cow replacements is a good practice if there is inherent capacity for milk production in the herd.

Milk Marketing. The development of every-other-day delivery of milk was begun in Boston in January, 1942. The Massachusetts Milk Control Board decreed that starting on March 15, 1942, no milk dealer could sell milk to retail customers more often

than once in two days. Considerable progress on every-other-day delivery has been made by the larger dealers in the Maine markets, according to a study made by George F. Dow. The average reduction in mileage is about 35 per cent where the retail routes are divided with each half served on alternate days. Producer-distributors who can handle their entire routes on alternate days could reduce their mileage about 50 per cent. The reduction in mileage results in an average saving in motor truck costs of 0.18 cent per quart of retail milk. This is computed from a study that showed the total cost of operating motor trucks for milk distribution was 0.82 cent per quart. Of this cost, approximately two-thirds or 0.51 cent was for variable costs. These variable costs can be reduced an average of about 35 per cent by the decrease in mileage, or a saving of approximately 0.18 cent per quart of milk.

Costs for labor in delivering milk to consumers cannot be reduced one-half by every-other-day delivery because double orders of milk must be delivered to each consumer. This requires more time and work for each delivery than for the original daily orders per customer. There also is no reduction in the time required in making collections from consumers for milk delivered. Dealers report that their routemen are able to save only one to two hours a day under the new setup, and at the present time there has been no reduction in the number of men employed or in the cost for labor. It is possible, however, that labor may be used more efficiently and that labor costs may be reduced a maximum of about one-half cent per quart of retail milk.

Some of the savings from increased efficiency in the use of motor trucks and man labor may be offset by increases in the costs for supplies, equipment, taxes, additional bottles, and extra refrigeration space. There is also the possibility that consumers may shift from retail routes to store purchases of milk during the summer months. Such a shift would decrease the volume of milk sold on retail routes and would tend to increase unit costs of retail distribution. This latter tendency, however, may be offset to some extent by a decrease in the number of distributors as the shortage of tires, gasoline, and labor becomes more serious. Although the total saving from every-other-day delivery is not large, less than one-half cent per quart, it should reduce the need in some markets for increases in milk prices to consumers as a result of increases in other costs of distribution.

Additional savings in milk distribution have been possible as a result of a change to daylight delivery and the elimination of special deliveries. By making daylight deliveries the routemen can collect money from consumers on the same trip as they deliver milk. They can at the same time supply the consumers' requests for additional milk or cream without making a special delivery.

FEED PRODUCTION

The State of Maine can be, under normal weather conditions, self-sufficient in the production of forage for dairy animals. The availability of good pasture is a very important item in the economical production of milk. Most of the concentrates probably will continue to come from outside the State. It is possible, however, that some concentrate feed such as corn, oats, wheat, barley, buckwheat, or millet, may be grown for use in supplementing rations purchased. The locally grown crops may be useful in fortifying a ration since the varieties can be selected on the basis of known nutrient values. They also can be ground in comparatively small quantities at a time, and will thus provide whole ground grain in the ration.

Grassland. The approximate yield of 4 per cent milk equivalent per acre from untreated, native pasture is 700 pounds per acre.[3] The production per acre can be increased to 5,000 pounds or more of 4 per cent milk equivalent through the liberal fertilization of the pasture, according to the results of experiments conducted by Delmar S. Fink and Paul Mosher. In order to gain further information about the yield of grassland, under a wider variety of dairy farm conditions and in an attempt to get a broader appreciation among farmers of the milk producing capacity of liberally fertilized grassland, the Experiment Station and the Extension Service are cooperating with the dairymen of the State and several fertilizer companies in a series of pasture improvement demonstrations. These test demonstrations are to be conducted over a period of several years. The data for the first year of this program are given in Table 1.

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[3] Me. Agr. Exp. Sta. Bul. 405: 459. 1941.

TABLE 1.

First Year Results of Pasture Improvement Demonstrations in Maine Conducted in Cooperation with Dairymen and Several Fertilizer Companies. All Data on Acre Basis.

Demonstrator		Fertilizer (including adequate liming) applied	Total lbs. T.D.N. required by milch cows and dry stock	Lbs. T.D.N. from grain and other barn feed	Lbs. T.D.N. from pasture, or yield of pasture in T.D.N.	Per cent T.D.N. from pasture	Yield of pasture		Total lbs. of milk (4%) produced while cows were on pasture
Name	Address						Standard cow days from pasture feed only	4% milk equiv. from pasture feed only	
			Native Pasture						
O. Field	Greene	850, 7-7-7	1658	316	1342	80.9	83.9	2098	2142
O. Field	Greene	None	388	52	336	86.6	21.0	525	420
E. Warren	Lisbon Falls	750, 8-16-20	1037	192	845	81.5	52.8	1320	1035
E. Warren	Lisbon Falls	None	342	81	261	76.2	16.3	408	522
J. Conant	Canton	600, 10-10-10	4193	1204	2989	71.3	187.0	4675	7514
J. Conant	Canton	500, 47% Super	2508	675	1833	73.0	115.0	2875	4573
J. Conant	Canton	250, 47% Super	1029	289	740	72.0	46.0	1150	1802
G. Colby	So. Paris	600, 10-10-10	3548	1149	2399	67.6	150.0	3750	5000
A. Cummings	Oxford	500, 8-16-16	1296	434	862	66.0	54.0	1350	1911
H. Gilbert	Farmington	500, 8-16-16	2997	1032	1965	65.5	164.0	3075	5292
H. Porter	Houlton	1000, 6-6-6	2986	527	2459	82.4	154.0	3850	5118
H. Porter	Houlton	None	2535	442	2093	82.5	131.0	3275	4305
H. Ward	Thorndike	550, 8-16-16	5852	2627	3225	55.1	202 0	5050	8292
F. Goff	Hollis Ctr.	600, 8-16-20	6155	3712	2443	39.7	153.0	3825	10225
W. Manchester	Machias	750, 5-9-8	3212	900	2312	72.0	144.5	3612	4464
W. Manchester	Machias	None	2465	504	1961	79.6	122.6	3065	3619
H. Page	Bangor	500, 8-16-16	1498	435	1063	71.0	66.0	1650	2644
H. Page	Bangor	None	1023	308	715	70.0	45.0	1125	1707
H. Crane	Lamoine	600, 10-10-10	1956	632	1324	67.6	82.7	2068	3268
Expt. Station	Highmoor	1000, 10-10-10	4020	715	3305	82.2	207.0	5175	4491
Expt. Station	Highmoor	None	471	None	471	100.0	29.0	725	Heifers
			Hay Field Previously						
J. Eagles	Fort Kent	750, 10-10-10	3448	1132	2316	67.2	145.0	3625	5309
J. Moore	Skowhegan	520, 8-16-16	3111	692	2419	77.8	151.0	3775	4494
J. Moore	Skowhegan	520, 8-16 16	3176	990	2186	68.8	137.0	3425	4503
W. Spear	Waldoboro	600, 10-10-10	2202	866	1336	60.7	83.5	2088	3795
			Oats—Ladino Seeded						
E. Hill	Machias	750, 5-9-8	1336	311	1025	76.7	64.1	1602	2078
C. Parker	Sebec	600, 8-16-16	2213	232	1981	90.0	124.0	3100	3184
W. Libby	Sebago Lake	500, 8-16-16	737	217	520	71.0	32.5	812	1312
Expt. Station	Highmoor	10 tons manure	1525	298	1227	80.5	76.7	1918	2353
			Ladino Clover						
M. Perkins	Albion	500, 8-16-16	5559	3271	2288	41.2	143.0	3575	9632
H. Cummins	E. Holden	500, 8 16-16	4109	1115	2994	72.8	187.0	4675	6704

All of the yield figures were derived in exactly the same way as are the pasture yields determined at Highmoor Farm, using the method of Knott, et al.,[4] except that live weight increases or decreases were not considered in the pasture demonstrations. The yield figures for the various demonstrations would be slightly larger, for the most part, if it were conveniently possible to consider live weight increases.

The milk yields for the various pasture demonstrations show wide differences. This was partly due to wide variations in moisture conditions throughout the State during the summer of 1941, but is mostly an expression of previous soil management practices. A number of the pastures had received previously some treatment, and in these instances 3,000 pounds or more of milk equivalent was produced per acre. Pastures which produced about 1,000 pounds or less of milk equivalent per acre had not been fertilized previously and neither had they been limed so far as is known.

The total milk yield figures were obtained directly from records kept by the cooperating farmers. In some instances the total amount of milk produced on the various pastures is far in excess of that accounted for by the pasture feed alone. Under these conditions heavy supplementary feeding was practiced while the cows were on the pasture. The need for this supplementary feeding is an expression of a lack of sufficient pasturage, due in some instances to severe droughty conditions (parts of Maine experienced the driest season on record in 1941), but for the most part it was due to a lack in planning for sufficient pasturage.

Some of the pastures carried young stock and larger numbers of dry cows which received no supplementary feed. Under these conditions the milk equivalent, accounted for by the pasture feed only, approaches or exceeds the total amount of milk produced on the pasture. For example, the check or no treatment paddock at Highmoor Farm (see Table 1) is grazed only by dry heifers. Their calculated consumption of T.D.N. per acre while on the check paddock would feed a standard cow for 29 days with a resulting production of 725 pounds of 4 per cent milk per acre. On the Highmoor Farm pasture plots it appears that about sixty pounds

[4] Knott, J. C., R. E. Hodgson and E. V. Ellington. Methods of Measuring Pasture Yields with Dairy Cattle. Wash. Agr. Exp. Sta. Bul. 295. 1934.

each of N, P_2O_5, and K_2O should be returned to an excellent pasture soil each year to keep it in excellent production.

These data clearly substantiate the more detailed yield figures being reported from the grazing trials at Highmoor Farm, and further focus attention on the need for soil fertility improvement and maintenance of grassland as well as the need for planning for sufficient pasturage.

Forage Crops. Several grass-legume associations, as pasture, are being studied by Delmar S. Fink and Paul Mosher. These trials have been in progress only a few years and definite conclusions are hardly warranted. It can be said, however, that the ladino clover-timothy association appears to have a wide range of adaptability and serves as a very satisfactory crop for silage, hay, and pasture in the course of one season.

In a test being made by W. F. Dove on the palatability of forage crops, the ladino clover has rated very high in this respect. Among six varieties of clover, four varieties of alfalfa, and four varieties of sweet clover there was a difference in palatability by variety. Also, the clovers, alfalfas, and sweet clovers appear to group into preference values by crops.

Grass Silage. The production and feeding of grass silage is a matter of considerable interest and of importance to the dairy industry. Studies are in progress by Delmar S. Fink, Bernie E. Plummer, Jr., and Paul Mosher as a means for obtaining information on the value of this practice. Grass silage was made at Highmoor Farm during the latter part of June, 1941, as follows:

Silo 1—First crop ladino clover-timothy, 29.8 tons, cut in partially air dried with thirty pounds of dilute phosphoric acid (ten pounds of 75 per cent food-grade phosphoric acid to twenty pounds of water) added per ton.

Silo 2—First crop ladino clover-timothy, 22.6 tons, cut in partially air dried with twenty pounds of dilute propionic acid (five pounds concentrated propionic acid, density 0.992, to fifteen pounds of water) added per ton.

Silo 3—First crop ladino clover-timothy, 20.2 tons, cut in partially air dried without the addition of a preservative.

Every attempt was made to cut the material into the silos when at about thirty-five per cent dry matter content. This proved to be a practical impossibility because of extremely hot and dry

weather, and as a result much of the material went into the silos with forty, and some with as high as fifty, per cent dry matter content. Spoilage, limited almost entirely to mold, was large in all three silos, *i.e.*, 21.3 per cent for silo 1, 22.0 per cent for silo 2, and 22.1 per cent for silo 3.

The difficulties encountered in attempting, and in a large measure failing, to get the material into the silos before it contained more than 35 per cent dry matter should not be considered normal. For example, in 1940 from several to upwards of 24 hours were required to air dry grass in the windrow to approximately 35 per cent dry matter content, in place of less than two hours as was frequently the case in 1941. Grass should be made into hay during hot and dry weather, particularly when the crop is suffering for lack of moisture prior to cutting. This would seem advisable in view of the practical difficulties of getting all of the material into the silo under 35 per cent dry matter content, and in view of the almost certain spoilage of material put into the silo with appreciably more than 35 per cent dry matter content.

There was no evidence that either phosphoric acid or propionic acid, in the amounts used, prevented spoilage if the material contained more than 35 per cent dry matter. Good silage coming out of each of the silos carried from 32 to 34 per cent dry matter and none of the silage carried less than 32 per cent.

No harmful effects were observed from liberal feeding of the propionic acid silage or the phosphoric acid silage over a continuous feeding period of eleven weeks to two groups of animals (six cows and six heifers in each group).

The cows on propionic acid silage (average weight 955 pounds) consumed an average of 38.2 pounds of silage (40.8 per cent dry matter) per day in addition to 6.41 pounds of grain and 4.48 pounds of hay. The cows on phosphoric acid silage (average weight 935 pounds) consumed an average of 42.4 pounds of silage (40.7 per cent dry matter) per day in addition to 6.33 pounds of grain and 4.63 pounds of hay. There were no significant differences in gains in live weight or in milk or butterfat production between the two groups. The cows on propionic acid silage averaged 19.9 pounds of milk and 0.98 pound butterfat per day, while the cows on phosphoric acid silage averaged 20.0 pounds of milk and 1.1 pounds of butterfat per day.

The heifers on propionic acid silage (average weight 469 pounds) consumed an average of 20.9 pounds of silage per day in addition to 1.9 pounds hay and gained 0.83 pound per day. The heifers on phosphoric acid silage (average weight 468 pounds) consumed an average of 21.7 pounds of silage in addition to 1.9 pounds hay and gained 0.86 pound per day.

Grain Crops. Corn. Certain flint-dent hybrids obtained from the Wisconsin Agricultural Experiment Station several years ago by R. M. Bailey have continued to be outstanding in the variety trials at Highmoor Farm. These hybrids are almost as early maturing as our native flints. They are definitely superior in yielding capacity and in plant type. Sufficient hybridized seed was produced to place these hybrids in cooperative trials with approximately 25 growers in 1941. The return questionnaires indicate that nearly all of the growers considered the hybrids promising for Maine and were anxious to try them again in 1942. It is expected that a limited quantity of seed will be available for sale next winter by the Station to supply growers for 1943 planting.

THE REGIONAL PASTURE LABORATORY

A Regional Research Laboratory for Research into Laws and Principles Underlying Pasture Improvement in the Northeastern Part of the United States was approved by the Secretary of Agriculture on February 20, 1936. This laboratory is located at State College, Pennsylvania. This is one of nine such laboratories established under the Bankhead-Jones Act of June 29, 1935. These laboratories provide a joint Department of Agriculture and State Agricultural Experiment Station attack on problems of regional or national importance. Following is the summary report of the Pasture Laboratory for the fiscal year ending June 30, 1942.

"The Northeastern States form the great market milk region of the United States. In any dairy program pastures afford the cheapest source of feed and produce the most profitable returns of all the available feeding stuffs used for the maintenance of animals. The importance of maintaining a milk supply in line with increased war requirements and market demands in this region necessitates an abundant supply of low-cost feed as a means of economical production. In recent years milk production in the

region has been inadequate due chiefly to normally low feed supplies, a generally short pasture season, and a low carrying capacity of existing pastures. Pasture improvement is essential, therefore, to agricultural betterment in the Northeastern region. Moreover, pasture improvement has a direct relation to problems involved in the control of erosion and in water-shed control.

"Because of the present war demands for a greater production of dairy and other livestock products, the laboratory is placing particular emphasis on the more practical phases of pasture management and the production of new strains of pasture plants. Plans have been formulated to increase strains that appear promising so that in the event they prove to be superior in further tests, sufficient seed will be on hand for distribution.

"In studies with Kentucky bluegrass, 144 new strains were selected for disease resistance, vigor under grazing conditions, and uniformity. Of these, 34 have been tested in plots two or more years. Seed increase plots of five of these strains were established in the spring of 1942, and increase plots of 11 others are being established at the present time. These seed increases will be available for distribution for testing elsewhere in the region and will serve as foundation seed stocks of those strains found suitable for distribution to the farmers.

"As a result of breeding white clover, one new strain is being increased and two additional strains will be ready for increase soon. Because of the increasing interest in Ladino clover in the region, the breeding program with this variety has been expanded. Superior appearing plants from commercial seed were grown in association with orchard grass in small plots. Eight of the better yielding and more persistent plants will be intercrossed in 1943 to provide seed for a new strain. Additional plant material has been collected from relatively old Ladino pastures for further breeding work.

"In order to study the effect of environment on the establishment of grass seedlings, eight pasture species were grown from seed under various artificial climates in special chambers constructed for this purpose. Marked variations were shown in the ability of pasture plants to grow under widely different temperatures. Sudan grass produced four times as much dry matter at temperatures of 70° to 85° F. as any other species used, but at 40° to 55° it was the only species which actually lost weight. Meadow fescue pro-

duced more growth than any other species at this low temperature, followed closely by brome grass and orchard grass. Temperatures of 55° to 70° were most favorable for the growth of meadow fescue, orchard grass, Kentucky bluegrass, and colonial bent, whereas a range of 70° to 85° was most favorable for Sudan grass and Ladino clover. At 85° to 100° F. only Sudan grass increased in weight. Some of the other species germinated but the seedlings did not survive six weeks at these high temperatures. These results will be extremely valuable in determining the adaptation of grass species to local environmental conditions and in providing seed mixtures that will produce satisfactory grass throughout the growing season.

"Studies of the effect of high soil temperatures on subsequent plant growth have been continued using different soils and incubating them under various conditions. It was found that incubating the soil at 45° C. or higher always gives poor subsequent growth of clover. In all cases the injurious effect was largely overcome by liberal applications of phosphate. The results, however, indicate that another factor or factors may contribute to the injurious effect of high soil temperatures. The solution of this phase of the laboratory program will contribute to the economic utilization of fertilizers on pastures.

"Recovery of plants that have been grazed is directly related to the chemical composition of the roots. When the tops of ryegrass were removed by cutting in laboratory tests, new growth of leaves began immediately and the reserve material of the roots and stubble were drawn upon to furnish the structural material of the new leaves. The roots and stubble did not regain their original composition until about four weeks after cutting. Under the conditions of this experiment, a second cutting before the expiration of the four-week period might seriously upset the equilibrium of the plant and lead to root starvation. A knowledge of the methods of management to insure adequate time for recovery of grazed pasture species will undoubtedly increase the total production of herbage during the grazing period.

"The laboratory has attained some measure of success in treating Sudan grass and alfalfa seeds with protective dusts that prevent damping-off by soil-borne organisms. When this procedure has been perfected, farmers will find it possible to obtain the same stand of grass with less seed than is now being used."

PUBLICATIONS

Further information on any of the research of the Experiment Station may be had by inquiry directed to those carrying the work of particular interest. The following list of publications deals with the dairy industry:

An Economic Study of the Production and Utilization of Milk in Maine. Me. Agr. Exp. Sta. Bul. No. 367.

An Economic Study of the Collection of Milk and Cream in Maine. Me. Agr. Exp. Sta. Bul. No. 373.

Costs and Returns in Operating Milk and Cream Collection Routes in Maine. Me. Agr. Exp. Sta. Bul. No. 374.

A Study of the Causes of Nutritional Deficiency Diseases in the Livestock and Inhabitants of Maine with Possible Corrective Methods Secured from the Utilization of Maine Fishery Products and the Production of Superior Foods. Me. Agr. Exp. Sta. Bul. No. 375.

An Economic Study of Milk Production Costs in Herds of Producer-Distributors in Maine. Me. Agr. Exp. Sta. Bul. No. 385.

An Economic Study of Milk Distribution in Maine Markets. Me. Agr. Exp. Sta. Bul. No. 395.

The Organization and Management of 95 Dairy and Cash Crop Farms in Androscoggin and Oxford Counties, Maine. Me. Agr. Exp. Sta. Bul. No. 398.

Receipts, Utilization, and Prices of Milk and Cream in Maine Milk Control Areas. Me. Agr. Exp. Sta. Bul. No. 399.

Farm Management on Central Maine Farms with Dairy Enterprises. Me. Agr. Exp. Sta. Bul. No. 408.

POULTRY RESEARCH

The poultry industry provides the third largest source of farm income in Maine. Poultry is kept on about half of the farms and, on 7 per cent, poultry products provide the major source of farm income.

ECONOMICS OF THE POULTRY INDUSTRY

Information was obtained during the summer of 1941 by George F. Dow from 86 poultrymen in the more important poultry areas of Maine. The data covered the year ending June 30, 1941, and included, by months, the number of layers, dozens of eggs produced, the sale of hatching eggs, baby chicks, market eggs of various size, and live and dressed poultry; and also the care and quality of eggs, disease problems, marketing costs, and price variations.

This study will make available the information concerning the setup of the poultry industry in Maine, some of the marketing problems from the producers' standpoint, and may suggest more efficient methods in the marketing of eggs and poultry. A partial report is made here under the heading of "Egg Production in Maine."

Egg Production in Maine.[1] Of the income from the poultry enterprise 69 per cent comes from the sale of eggs and 31 per cent from the sale of poultry. Although poultry was kept on about one-half of all farms in Maine, it was the major source of farm income on only 7 per cent of the farms, but these specialized farms produced three-fourths of the total sales of poultry and eggs. Production was most intensive along the coast from Kittery to Winterport, extending northward to Auburn and Augusta. Maine poultrymen have good outlets for market eggs, either locally or at Boston, and also have an excellent demand for hatching eggs and baby chicks.

Improvement should be made on some farms in the care and handling of eggs, as indicated by the fact that 3 per cent of the producers collected eggs only once a day, 40 per cent did not use

[1] More details will be found in Me. Agr. Exp. Sta. Bul. 412.

open wire baskets for prompt cooling of eggs, one-third cooled eggs less than eight hours before packing, and 15 per cent stored eggs above ground without adequate cooling facilities in some instances. Although dirty eggs were not a serious problem to producers because they were cleaned and sold without any price discount, it would have been preferable if one-fifth of the producers had cleaned their eggs without using a damp cloth or washing them in water.

Market eggs were candled regularly by 17 per cent of the poultrymen, requiring 30 minutes to one hour per case. For a few of the producers, farm candling was an unnecessary use of labor because their eggs were sold to Boston dealers who did not require nor pay a premium for candled eggs. Two-thirds of the poultrymen used hand scales in grading eggs for size, and one-third used automatic egg graders. Those using hand scales weighed 82 per cent of all eggs early in the laying season and 51 per cent during the remainder of the year. With the existing shortage and high price of labor, many producers doubtless could profit by training themselves to grade eggs carefully without weighing as many. The average time required to clean, grade, and pack 30 dozen eggs was 37 minutes in cases, or 48 minutes in cartons. There was a tendency for automatic graders to be used in the larger flocks and their use reduced the labor of grading and packing by one-third, resulting in a saving of about eight cents per case. Eggs need to be packed carefully to avoid breakage in transit, especially the larger eggs. The average breakage for a group of 22 producers shipping out-of-State was 1.8 eggs per case, and varied from 0.5 for peewees, 2.0 for large, 4.5 for very large, to 19.0 for double-yolked eggs.

The breeds of layers kept in the flocks included in this study by Mr. Dow were 69 per cent Rhode Island Red or New Hampshire, 18 per cent Plymouth Rock, 12 per cent Sex-Linked, and 1 per cent Broiler Cross. Very few Leghorns are kept in Maine due in part to the fact that they produce white eggs which bring one to two cents less per dozen than brown eggs sold at Boston or northern New England markets. There was very little difference among breeds in egg production per layer and in mortality. The eggs produced by the Sex-Linked flocks were 77 per cent "large" eggs as compared with 67 per cent by the flocks of Reds.

The number of layers per flock averaged 901 birds for the flocks included in this study as compared with 1,048 for the 329 flocks listed in 1941 as Pullorum Clean or Pullorum Passed, and 77 for all farm flocks reported for Maine in the 1940 Census. The smaller flocks of less than 300 birds had a slightly higher mortality rate and egg production per layer than the average for all flocks. In the larger flocks, a greater proportion of the eggs were sold as hatching eggs and as baby chicks.

Most of the hens were sold during July to October when hens began to molt and pullets became of laying age. The total number of layers per flock varied from a low of 680 layers in June to a peak of 1,088 in September to November.

Egg production per layer was 176 eggs for the year as compared with estimates of only 138 for the United States, 158 for the North Atlantic States, and 116 for the South Central States. Production per layer has increased in Maine 42 per cent since 1920-24, when only 126 eggs were produced per layer; and production can be improved further as indicated by the achievements of the better flocks included in this study and in the Maine Egg Laying Contest. Egg production per layer reached a seasonal peak in February and March when 57 eggs were produced daily per 100 hens as compared with a low of only 38 in September. The peak in total egg production was during December to February when production was 1.5 times that of July, the month of lowest production. The larger, more specialized flocks had more early-hatched pullets which caused an advance of two to three months in the seasonal variation of production, in comparison with estimated totals for all flocks in Maine and in other areas of the United States. There was not much difference between areas of the United States in the seasonal variation in the number of layers, but for egg production per layer and total egg production there was considerably more variation for the United States and the North Atlantic States than in Maine.

The proportion of all layers that were pullets increased from one-third in July to one-half in August, three-fourths in September, and 94 per cent during January to June. The results of other studies indicate that egg production was decreased considerably when old hens were kept through a second year of laying.

Of all eggs produced during the year, 68.5 per cent were large, 20.8 per cent were medium, 7.8 per cent were pullet, and

2.9 per cent were peewee eggs. The proportion of large eggs varied from 45 per cent of the total in September and October to 83 per cent during March to June. Other studies show that pullets during the first twelve months of laying produce about 57 per cent large eggs as compared with 78 per cent for flocks of hens. Pullets hatched during March and April have the greatest proportion of large eggs because they start laying late in the summer when weather is favorable and shift over quickly from small to large eggs.

About two-thirds of the pullets raised were hatched in February, March, and April, and only 3.7 per cent during June to December. The early-hatched pullets not only produced eggs over a longer period, but were laying during July to October when demand was strong and prices were relatively high. Nearly one-half of the poultrymen had pullets hatched over a period of three to four months or more, which was helpful especially in the larger flocks in utilizing brooder equipment, buildings, and labor more efficiently.

Nearly one-third of the poultrymen hatched their chicks using eggs from their own flocks; and about two-thirds purchased baby chicks. Of the baby chicks purchased, about 17 per cent came from out-of-State, primarily from Massachusetts, New Hampshire, and Connecticut.

The average mortality of layers, based on the average number of birds kept, was 19 per cent. "Colds" were reported by poultrymen during the year ending June 30, 1941, in 42 per cent of the Knox-Lincoln County flocks as compared with 20 per cent in the other areas. Such infection caused relatively little mortality but resulted in a severe drop in egg production for a two-weeks' period. Coccidiosis gave only occasional trouble, and paralysis or leucosis was not reported as very prevalent. Cannibalism was reported to be serious in only 2 out of 86 flocks. Maine flocks were relatively free from fowl pox, laryngotracheitis, cholera, and pullorum disease. Of 342 breeding flocks containing 353,884 birds tested for pullorum disease in 1940–41, only 35 birds were infected.

It was found that the production of hatching eggs was important in one-third of the flocks studied. The utilization of eggs sold by all the poultrymen was 70 per cent sold as market eggs, 21 per cent sold for hatching, and 9 per cent used for farm incubation. The men producing hatching eggs obtained 182 eggs annually per layer as compared with 172 eggs for the market-egg men. Home consumption of eggs included 1.5 per cent of all eggs produced and

amounted to eleven eggs per person a week. The eggs consumed at home were 75 per cent crax, 3 per cent dirty, 3 per cent irregular in shape, 2 per cent very large, 9 per cent pullet or peewee eggs, and 8 per cent good quality large or medium eggs. The volume of home consumption was influenced by the size of the family and the size of the flock.

Additional material on (1) hatching eggs and baby chicks; (2) live and dressed poultry; and (3) market eggs is being prepared for other reports in this study.

POULTRY FEEDING

The research of W. Franklin Dove on Maine fish meal products[2] for poultry has been responsible for the development of a feed which supplies a protein concentrate for the poultry ration and at the same time supplies vitamins A, D, and G. This protein concentrate as 15 per cent of the poultry ration will supply all of the vitamin D that is needed and in addition about one-half of the vitamin G that is commonly supplied by the milk in the ration. If this fish meal is used it will be necessary to use only half as much milk as is ordinarily used to supply vitamin G in the ration. At a time when milk is scarce this information can be highly useful. Furthermore, protein from fish meal is cheaper than protein from a meat source.

More recent research in poultry feeds has been with the grains in the ration. It is possible in some sections of the State that most or all of the grain in the poultry ration may be produced locally and in most areas some of the grain can be grown. It is considered feasible to grow at least enough grain locally to supply a portion of the poultry ration as whole-ground grain. Since the varieties of these crops vary in nutrient values they are being tested singly and in combinations in order to discover which varieties are the most valuable. The crops being studied by W. Franklin Dove include field corn, buckwheat, millet, oats, barley, and wheat. A ration is now under test composed entirely of Maine-produced feeds. The results of these studies should be helpful in improving the poultry feeding practices.

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[2] Me. Agr. Exp. Sta. Bul. 375.

THE REGIONAL POULTRY RESEARCH LABORATORY

The establishment of this Regional Poultry Research Laboratory was approved by the Secretary of Agriculture for the purpose of improving the viability of poultry. It is located at East Lansing, Michigan. The Laboratory program of research was outlined by, and is conducted in cooperation with, 25 experiment stations of the North Central and Northeastern States. The following report is made by the Director of the Laboratory, Mr. Berley Winton, and covers the work for the fiscal year ending June 30, 1942.

The Mortality of Chickens and Its Significance. At 18 standard egg-laying tests, located in 16 States and including 15,704 chickens, there was an annual mortality during the laying year of 1940-41, of 19.45 per cent. The range in losses was from a low of 12.79 per cent for one of the New York tests to a high of 27.44 per cent for the Michigan test. In the Storrs, Conn., test, which is patronized by poultrymen from practically every section of the United States, there was a mortality of 244 hens, or 18.77 per cent, among the 1,300 birds entered, 38.5 per cent of this loss being caused by the avian-leukosis complex (fowl paralysis), the particular disease condition with which this Laboratory is now concerned. The losses caused by the avian-leukosis complex at the Storrs test are probably representative of the mortality on farms throughout the United States. On the basis of this information and that provided by the U. S. Bureau of Agricultural Economics relative to the number of hens on farms in April 1942, the mortality in the United States during the fiscal year 1942 was more than 54 million hens, 21 million of which succumbed from the avian-leukosis complex.

The monetary value of these losses totaled at least 60 million dollars, not taking into consideration the mortality of adult males and young stock and the decrease in egg production that can be ascribed directly to an unthrifty condition, caused by the onset of disease. An annual mortality of approximately one adult chicken out of every five raised is a major handicap to the poultry industry. This is especially true when the Nation is at war and needs an abundance of eggs and poultry meat. This loss in mortality is a challenge to science and to this Laboratory in particular.

Objectives of the Laboratory. The current research objectives

of this Laboratory are to develop measures for the prevention and the control of the avian-leukosis complex (a disease condition commonly known as fowl paralysis), through studies in genetics, pathology, physiology, nutrition, and management. The research at the Laboratory is integrated and there is no clear-cut line of demarcation among the different branches of science represented in the program.

Progress of Research at the Laboratory.[3] Mortality Caused by the Avian-Leukosis Complex in the Breeding Stock. Of the 1,130 chickens raised for prospective breeding purposes at the Laboratory in 1941, 21 per cent died from the avian-leukosis complex before they reached 300 days of age. The mortality among the chickens raised in 1939 and in 1940 under similar environmental conditions and for the same length of time was 13.7 per cent and 10.2 per cent respectively. The increase in the loss of chickens raised in 1941 over the two previous years with the same disease complex may have been influenced in part by the inherent qualities of the parental stock used to produce them. They were selected by using the progeny test for either a high or low incidence of the avian-leukosis complex. The occurrence of the disease among their brothers and sisters which were inoculated was also used as a measure in selecting them. The higher mortality and the wider range in the incidence of the disease among the matings suggest that genetic segregation is now taking place. A total of 18 individual matings, consisting of 18 males and 100 females, produced the chickens used in the 1941 experiment. The success of the matings from the standpoint of selecting birds which are resistant to the disease complex can be determined only by ascertaining the ability of their progeny to survive over a long period of time.

At the close of the 300-day period, a summary of the results indicates that the various matings produced chickens showing a much wider range in the incidence of the avian-leukosis complex than had been shown from the matings during the two previous years. Losses of the 1941 stock ranged from a low of no mortality in mating No. 14 with 14 progeny to a high of 45.5 per cent of

[3] A more complete account of the progress of research at the Laboratory and of the projects at the cooperating State Agricultural Experiment Stations is given in the report of the Second Collaborators' Conference at the Regional Poultry Research Laboratory, October 21, 22, and 23, 1941.

156 birds in mating No. 8. The losses of the progeny of the different matings are given in Table 1.

Judging from the mortality pattern given by the chickens hatched in 1939 and in 1940, losses from the avian-leukosis complex among those hatched in 1941 will continue unabated for a much longer period than 300 days.

TABLE 1

Mortality Caused by the Avian-Leukosis Complex among Progeny of 1941 Matings

Mating No.	Number of Progeny	Mortality in 300 days (Per cent)	Mating No.	Number of Progeny	Mortality in 300 days (Per cent)
1	62	8.1	10	95	14.7
2	83	20.5	11	32	37.5
3	44	6.8	12	54	29.6
4	51	15.7	13	31	3.2
5	56	12.5	14	14	0.0
6	60	18.3	15	47	14.5
7	124	12.9	16	59	15.3
8	156	45.5	17	54	11.1
9	77	19.5	18	31	19.4
		Total (all 18 matings)------		1,130	21.1

Promising Families. It is encouraging to know that there are several families (family—the progeny of a given sire and dam) among the matings that show less than 10 per cent mortality, whereas other families have a range in mortality of 50 to 85 per cent from the disease complex. To illustrate more specifically, only 2 individuals out of a total of 20 chickens in family No. 483 died during the 300-day period and the avian-leukosis complex was not the cause of these losses. In family No. 569, consisting originally of 18 chickens, there was a total mortality of 15 birds, 14 of which died with manifestations of the avian-leukosis complex. Furthermore, much hope is held for two particular families, the viability of which has been most unusual during the past three generations. The parents of the two families came from two strains of the original chickens hatched at the Laboratory in 1939. They were selected originally as breeders because of the low incidence of the avian-leukosis complex among their brothers and sisters. They have maintained this standard through two successive brother-sister

inbred generations. One of the families is represented by 38 birds, and the other by 48 birds, not including those hatched in 1942.

Embryonic Mortality. An examination of the hatchability data for 1941 shows that in general a higher frequency of anatomical defects occurred among the more closely bred embryos than among the less closely bred ones. However, a study of individual matings revealed closely related individuals which produced embryos with hatchability as high or higher and frequencies of defects as low or lower than were produced by matings of less closely related birds. Thus, in keeping with theory, selection can be made for high hatchability among inbred families with the added advantage (over outbred matings) of uncovering quickly many inherited defects which may be ultimately eliminated.

Other Common Diseases under Control. Pullorum disease has not been detected in the birds hatched from eggs received for initiating the project nor in the hundreds of birds which have been tested and subjected to autopsy. During the last four years chickens in large numbers were kept at the Laboratory without becoming infected with fowl pox, bronchitis, laryngotracheitis, colds or other respiratory diseases, or infested with lice, mites, roundworms, or tape worms. Freedom from these infectious diseases and common parasities may be attributed to the rigid quarantine measures, methods of management, and sanitation practices introduced at the time the research program was started at the Laboratory in 1939.

Quarantine Measures: Access to the different poultry buildings, including the feed house, is limited to the technical staff and those who take care of the chickens. All workers are required to change their clothes and shoes before entering any poultry house. A second change is made before any of the pens are entered. These procedures are reversed when leaving a pen or a house. In addition, door mats placed in shallow pans and saturated with disinfectant are used extensively in houses and between pens in several of the buildings. Furthermore, employees are asked not to keep chickens on their own premises and to stay away from other flocks and places where chickens are handled. The quarantine rules also forbid the caretakers' going from the control side of the plant, where the breeding work is done, to the other side where inoculated birds are maintained for studies in pathology, and vice versa. In the breeding operations, chickens from outside flocks are not used.

Methods of Management: The chickens, without exception, are brooded and maintained in complete confinement. That is, they are kept within buildings, the windows and doors of which are carefully and adequately screened against flies, mosquitoes, and other insects. Furthermore, sparrows are not permitted to nest in or about any of the buildings. Feed is delivered to the Laboratory in new bags and is taken to the different houses in covered cans. Litter which has not been exposed to other poultry or wild birds since it was originally manufactured is used. The droppings and litter are removed in covered cans and burned in the incinerator.

Sanitation Practices: Frequent cleaning and the use of water under pressure aid greatly in keeping the buildings and equipment clean and sanitary. In certain houses the use of wire panel floors facilitates keeping the chickens from coming in contact with the droppings and contaminated litter. Where litter is used, the cleaning process is done often in order to keep the pens in good condition. All feed is supplied in open hoppers, and running water in each pen facilitates keeping fresh, clean water before the birds all the time.

The measures mentioned above are supplemented by fumigation of incubators and other equipment and by the use of liquid disinfectants.

Coccidiosis Present. Other than the avian-leukosis complex, coccidiosis is the only known disease with which the Laboratory birds have been affected during the last four years. The coccidial infection is believed to have been introduced in the fall of 1939 through either the feed or the litter.

Reproducing the Avian-Leukosis Complex. Two manifestations now considered to be a part of the avian-leukosis complex, which are (1) an enlargement of the bones (osteopetrosis) and (2) a change in the blood picture (erythrogranuloblastosis), have appeared in only two or three cases among the chickens raised for breeding purposes. However, these manifestations of the disease complex have been reproduced readily by inoculation. These conditions suggest that the agents involved do not spread in the same manner as those responsible for lymphomatosis as manifested by paralysis (neural lymphomatosis), blindness (ocular lymphomatosis), and big liver disease (visceral lymphomatosis), etc.

Reproducing the avian-leukosis complex for further study in pathology by inoculation has been continued during the year. It

has been demonstrated that the incidence of the avian-leukosis complex can be increased and the time required for clinical manifestations to develop for the disease complex can be reduced by inoculation of material from affected birds. It is recognized that the disease caused by inoculation may not be comparable to that which occurs spontaneously.

Further evidence has been obtained to show that the four different sources of inocula used previously gave positive but variable results. Of 310 chickens inoculated with the No. 1[4] (lymphomatosis) agent, 91, or 29.4 per cent, succumbed to the disease. However, 17, or 21.8 per cent, of 78 non-inoculated birds showed manifestations of the same disease. When 85 chicks were inoculated with the No. 2[4] (lymphomatosis) agent, 33, or 38.8 per cent, developed the disease complex. Of the 9 non-inoculated birds in this lot, 2 died with the disease. When the No. 3[4] (lymphomatosis-osteopetrosis) agent was used, 137, or 64.3 per cent, of 213 birds died with the disease and only 5, or 11.9 per cent, of the 42 non-inoculated birds of this lot became affected with the avian-leukosis complex. Inoculation with the No. 4[4] (erythrogranuloblastosis) agent gave the most pronounced results when 184, or 73.6 per cent, of 250 chickens developed the disease. Not one of the 16 non-inoculated birds became affected.

Most of the inoculated chickens used in these experiments were injected intravenously with heparinized whole blood in advance of reaching three weeks of age. The observation period following inoculation ranged from two months for those receiving the No. 4 inoculum to more than two years for those receiving the other strains of the causative agent. The variability in the amount of infection following inoculation with the four different strains of inocula emphasizes the need for determining and eliminating the factors responsible for such variables. There is evidence at present to support the belief that the following factors may influence the results obtained from different inocula: (1) The stage of the disease in the donor, (2) susceptibility of the recipient, (3)

[4] The No. 1 and the No. 2 strains of inocula came from birds of different flocks. These birds had typical manifestations of neural lymphomatosis. Strain No. 3 was derived originally from 3 birds of another flock which manifested ocular lymphomatosis, and Strain No. 4 was supplied by the Animal Disease Station, Beltsville, Maryland, having been subjected to numerous serial passages in chickens.

quantity of inoculum, (4) the route of inoculation, (5) the age of the recipient at the time of inoculation, and (6) the relationship of the donor to the recipient.

Occurrence of Different Types of the Avian-Leukosis Complex. A summary of 700 positive cases of the avian-leukosis complex shows the prevalence of the different types of the disease or combinations of types. There were 371 cases from birds which were inoculated with lymphomatosis material, 150 from birds which were not inoculated but were exposed by contact with inoculated birds, and 199 were cases among the non-inoculated birds which were raised in isolation. The cases were determined to be positive for lymphomatosis by either gross or microscopic examination, or both.

A total of 515, or 73.5 per cent, of the 700 cases had only one type of lymphomatosis and 185, or 26.4 per cent, of the cases showed a combination of types. The 515 cases with only one type of the disease were classified as follows:

Neural lymphomatosis	30.48%
Visceral "	58.44
Ocular "	9.51
Osteopetrotic "	1.55

Since microscopic examinations have not been made in all 515 cases, it is possible that the percentage figures for the different manifestations will be altered upon final diagnosis.

It is interesting to note that a single type of the disease occurred more frequently among the non-inoculated groups and the combination of types occurred more frequently among the inoculated birds. The osteopetrotic type was limited to strain 3 of the inoculated groups.

Gross and Microscopic Examinations. In an analysis of 2,000 autopsies of chickens which ranged in age from 1 to 1,096 days, it was shown by gross examination that 1,116 cases were positive for the avian-leukosis complex, 92 cases were questionable, and 792 cases were negative. The microscopic examination of the same cases classified them as 1,521 positive for the avian-leukosis complex, 84 questionable, and 395 negative. Final microscopic diagnosis classified 349, or over 44 per cent, of the 792 grossly negative cases as positive for the avian-leukosis complex, 72, or

about 9 per cent, questionable and 371, or almost 47 per cent, negative.

Distribution of Microscopic Lesions. The location of lesions was determined in 326 chickens which were grossly negative for lymphomatosis but positive on microscopic examination. The results of this study are given in Table 2.

It will be observed that other than the eye, the nerves and the adrenal ganglion contained the largest number of positive lesions. High percentages of visceral lesions were located in the liver, the gizzard, the adrenal, the heart, and the kidney. It will also be noted in Table 2 that the highest percentage of single positive tissues from which it was possible to make a diagnosis was found in the brachial plexus, the sciatic nerve, the adrenal ganglion, and the undesignated nerves.

Anatomy of the Avian Eye. In pursuing a study of ocular lymphomatosis, specific information was obtained on the physiological anatomy of the eye of the White Leghorn chicken. It was found that in the formation of the scleral plates there are a variable number of sclerotic rings of solid bone which differ in size and shape. The variability in the arrangement of the plates may be due to embryo

TABLE 2

Distribution of Lymphomatosis Lesions in Tissues of Grossly Negative Birds and Single Positive Tissues from Which a Diagnosis was Made

Tissue	No. Tissues Examined	Positive		Questionable		Negative		Single Positive†	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Eye	15	9	60.00	2	13.33	4	26.66	5	33.33
Brachial plexus	122	69	56.56	2	1.64	51	41.80	15	12.29
Sciatic nerve	147	80	54.42	2	1.36	65	44.22	25	17.00
Adrenal ganglion	150	78	52.00	2	1.33	70	47.67	17	11.33
Undesignated nerve*	85	43	50.59	0	0.00	42	49.41	23	27.05
Liver	268	121	45.15	18	6.72	129	48.13	14	5.22
Brain	34	14	41.18	1	2.94	19	55.88	1	
Gizzard	13	5	38.46	0	0.00	8	61.54		
Adrenal	128	39	30.47	5	3.91	84	65.62	8	6.25
Heart	275	83	30.18	15	5.46	177	64.36	4	1.45
Kidney	244	58	23.77	11	4.51	175	71.72	4	1.63
Lung	93	17	18.28	2	2.15	74	79.57	1	
Duodenum	210	36	17.14	9	4.29	165	78.57	3	1.42
Ovary	157	26	16.56	7	4.46	124	78.98	1	
Spleen	238	39	16.39	24	10.08	175	73.53	1	
Pancreas	213	34	15.96	6	2.82	173	81.22		
Ileocecal valve	109	11	10.09	6	5.51	92	84.40		
Testicle	69	5	7.25	1	1.45	63	91.30	1	

* Unable to differentiate between sciatic and brachial plexus.

† Single positive cases were those in which microscopic lesions were found to be present in only one of several tissues examined.

movement during embryonic development. The variation in the number of plates is suggestive of genetic influence but no proof of this hypothesis was found in the family groups examined.

Other Studies in Progress. Attention was directed during the year to studies designed to give more information on (1) the relation of sex to the avian-leukosis complex, (2) the nature of the agent or agents causing the various manifestations of the complex, and (3) the transmissibility of the disease under pen and individual cage environment.

In experiment No. 1 the objective is to determine if castration affects the susceptibility of male and female chickens to the avian-leukosis complex which is caused by natural infection or inoculation. This experiment is a sequel to a study of the mortality records of chickens hatched in 1939, which showed that up to 300 days of age there was a higher mortality from the avian-leukosis complex among the females than the males.

In experiment No. 2 the objectives are to concentrate the agent or agents and eliminate the inert and or the inactive as well as the inhibiting substances found in the material containing the agent or agents, and to determine (1) the viability and the stability of the agent or agents, (2) the chemical and physical properties of the agent or agents, and (3) the antigenic and the immunologic characteristics of the various purified and concentrated fractions or extracts of the agent or agents of the avian-leukosis complex.

In carrying on the transmission experiment certain complicating disturbances developed among the caged birds and it has been necessary to hold in abeyance this research. The disturbance is believed to be due to nutrition deficiencies, the lack of exercise, the amount and intensity of light, or a combination of these factors. The condition manifested itself in the form of leg involvement. The unusual conditions of the chickens which were held in cages from the time they were hatched until maturity are being investigated at this time.

PUBLICATIONS

Following is a list of publications that may be of interest to those wishing more information than is to be found in this report:

Egg Production in Maine. Me. Agr. Exp. Sta. Bul. 412.

Report of Progress for Year Ending June 30, 1941. Me. Agr. Exp. Sta. Bul. 405.

A Study of the Causes of Nutritional Deficiency Diseases in the Livestock and Inhabitants of Maine with Possible Corrective Methods Secured from the Utilization of Maine Fishery Products and the Production of Superior Foods. Me. Agr. Exp. Sta. Bul. 375.

FOODS AND NUTRITION

The subject of human nutrition is always one of major interest to many people. Its importance, however, is particularly emphasized during an emergency when large numbers of young people are subjected to physical examinations and many are found defective. There is the possibility that most of the physical and functional defects discovered in these examinations could be traced directly to poor nutrition. With this viewpoint and in view of variations in climate, soil, and food choices the nutritional problems are likely to vary from one area to another. It will be found desirable, therefore, to conduct the research in this field on an area basis in order to discover the particular needs of an area and to develop means of fulfilling these needs.[1]

NUTRITIONAL STATUS

Nutritional status can be judged on the basis of physical and functional measurements and, also, to some extent on the basis of the foods included in the diet. The data obtained are compared with standards described as normal in the case of physical or functional measurements and as optimum in the case of the diets.

Nutritional Status of Grade-School Children. It was found by Mary M. Clayton that the most common physical defects of the grade-school children in the towns of Mars Hill, Jonesport, Monmouth, and Newport were (1) bone defects (resulting from rickets), (2) flat feet, (3) colds, (4) inflamed gums, (5) enlarged or infected tonsils, (6) adenoids, (7) defects of vision, (8) defects of hearing (resulting from colds), and (9) underweight. Dental caries also was prevalent. The diets of many of the Newport children were below the standards for a "Good Diet"[2] in several food items, particularly milk, citrus fruits and tomato, leafy green and yellow vegetables, other fruits and vegetables, eggs, and whole grain cereal and dark bread. There was a tendency, also, for the diets to be too high in sugar and products made from

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[1] Me. Agr. Exp. Sta. Bul. 375, p. 195, 1935.

[2] H. K. Stiebeling and F. Clark. Food and life. Yearbook of Agriculture. U. S. Dept. of Agr. p. 332, 1939.

white flour, and too low in vitamin D. More details of these studies are given in Maine Agricultural Experiment Station Bulletin 405.

The data obtained on the weights of the children in the Newport study were used in a comparison of the McCloy[3] standards with the commonly used Baldwin-Wood[4] standards for this item. It was found that the McCloy method is very satisfactory for the majority of children although the standards appear to be somewhat high for overweight subjects and somewhat low for those extremely underweight. However, both of these weight abnormalities are easily observed. The McCloy standards for individual children were much more in agreement with Miss Clayton's estimate of proper weight than were the Baldwin-Wood standards. She explains this conclusion on the basis that the McCloy standards make allowance for age, skeletal build, and subcutaneous tissue, while the Baldwin-Wood standards are based only on age and height.

Nutritional Status of University of Maine Freshman Girls. This cooperative study,[5] begun in the fall of 1940, was continued in the fall of 1941. One hundred twenty-six State of Maine girls were given physical examinations by a physician[6]; dental examinations by Miss Dorothy Bryant, Associate Director of Dental Health for the State Department of Health and Welfare; and posture studies by Professor Helen Lengyel. Physical measurements, examination of the eyes for Bitot's spots[7] (probable evidence of present or past vitamin A deficiency), red blood cell counts, hemoglobin determinations, and salivary analyses also were made. A partial analysis of the data secured for 1940-41 and 1941-42 has been made by Miss Clayton and the results are given in Table 1.

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[3] C. H. McCloy. Appraising physical status: the selection of measurements. Univ. of Iowa studies in child welfare. Vol. 12, No. 2, 1936. Methods and norms. Vol. 15, No. 2, 1938.

[4] Baldwin-Wood tables issued by Iowa Child Welfare Research Station, State Univ. of Iowa. Iowa City, Iowa. Sept. 1924.

[5] Department of Home Economics of the Maine Agr. Exp. Sta., Department of Physical Education for Women of the University of Maine, and State Department of Health and Welfare.

[6] Dr. Walter L. H. Hall of Old Town.

[7] Medical evaluation of nutritional status. IV. The ocular manifestations of avitaminosis A, with especial consideration of the detection of early changes by biomicroscopy. H. D. Kruse. Public Health Reports 56, 1301–1324, 1941.

TABLE 1

Partial Summary of Results of Physical and Dental Examinations of University of Maine Freshman Girls. 1940–41 and 1941–42

	1940	1941
Total number examined	138	126
Per cent who were definitely underweight according to McCloy standards	21.0	22.2
Per cent who were definitely overweight according to McCloy standards	.7	2.4
Per cent who were definitely overweight according to Clayton's estimate	7.3	13.5
Per cent with hemoglobin under 85 per cent (14 gms. considered normal)	11.6	32.0
Per cent with red blood cell counts under 90 per cent	4.4	0.0
Per cent with acne	38.4	44.8
Per cent with Bitot's spots[7] in eyes (probable evidence of present or past vitamin A deficiency)	—	26.4
Average number carious teeth per mouth	1.8	1.6
Average number filled teeth per mouth	9.1	9.4
Average number teeth both carious and filled per mouth	.9	1.0
Average number decalcified areas per mouth	1.4	.5

It appears from these data that slightly over twenty per cent of the freshman girls are underweight but that a comparatively small percentage are overweight. Acne was the most common defect with 44.8 per cent of the girls in the 1941 study affected. Apparently vitamin A deficiency (as indicated by Bitot's spots in eyes) is prevalent since 26.4 per cent of the girls in the 1941 study were below normal in this test. This agrees with similar data obtained on University of Maine students in 1940 by W. Franklin Dove.[8] The average for carious teeth per mouth was slightly under two.

Questionnaires, regarding (1) home food production and preservation, (2) early and present diets, and (3) health, were answered by the girls and their mothers shortly before the beginning of the fall semester. The data are briefly summarized in Table 2. Doctor Clayton concludes that the mothers of the girls drank too little milk during pregnancy and that 20 per cent of the girls themselves had too little (less than one pint) of this healthful food. Almost 11 per cent of the girls drank no milk at all. The low consumption of milk probably is related to the occurrence of bone defects, resulting from rickets, and dental caries. There also was apparently an insufficient use of a reliable source of vitamin D throughout the pregnancy of the mothers and during the infancy and

[8] Me. Agr. Exp. Sta. Bul. 400.

childhood of the girls. This also is related to the occurrence of [illegible] [illegible] [illegible] (for vitamin A and [illegible]) [illegible] whole grain cereals and bread (for iron). The occurrence of dental caries [illegible] may be attributed partly to the [illegible] many sweets.

TABLE 2

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
Per cent of families having chickens	54.4
[illegible]	[illegible]
Per cent of families having vegetable gardens	53.3
Per cent of families who can and store vegetables	54.1
[illegible]	[illegible]
[illegible]	[illegible]
Average daily milk consumption per girl	1.4 pt.
Per cent who drank no milk	10.8
Per cent who drank ½ pint daily	9.2
[illegible]	[illegible]
Per cent who drank more than 1 pint daily	55.4
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Per cent whose mothers had drunk 1 quart or more milk daily [illegible]	[illegible]
[illegible] vitamin D during pregnancy	[illegible]

FOODS

Many data have been obtained indicating that several of the more important vitamins are inadequately supplied in many diets of Idaho people. Among those which probably can be supplied adequately from locally produced foods are vitamins A and C. Information is needed on the ability of humans to utilize the vitamins contained in these food products. Also it would seem desirable, where possible, to develop food crops with high values for the various important vitamins. This latter problem may well include high vitamin value feeds for livestock and poultry where these nutrients are transferred by the animals to the animal products consumed by humans.

Utilization of the Vitamin C in Raw Cabbage and in Home Canned Tomato Juice. The subjects for this study by Mary M. Clayton were four University students who ate all of their meals in the Home Economics Department during the fifty-one days of the experiment.

The cabbages used were of the Danish Ballhead variety and were obtained from a commercial cold storage plant in Bangor from Maine-grown stock. The cabbages showed fairly high initial vitamin C values (average 47.6 mgs. per 100 gms.). However, after they were stored for about a week in an electric refrigerator the values for vitamin C fell to about 25 milligrams per 100 grams. It was then considered desirable to secure another lot with which to finish the experiment. This latter lot averaged 53.9 milligrams per 100 grams. The amounts of cabbage which the subjects had to eat in order to secure 50 milligrams of vitamin C (two-thirds of their daily allowance) varied from 96.5 to 148 grams. The cabbage was eaten plain, immediately after it was cut from the head. Judging from the results of urine and blood analyses the subjects on this experiment utilized the vitamin C in the cabbage as well as they did pure vitamin C taken in pill form. The above results show that stored cabbage may be an excellent source of vitamin C. However, since the vitamin C content apparently varies greatly with storage conditions, it appears that ordinarily it would not be wise to depend upon raw cabbage as the *major* source of vitamin C in the diet. As shown previously (Maine Agr. Exp. Sta. Bul. 400, p. 234, 1940), losses in vitamin C also occur when raw cabbage is shredded, mixed with salad dressing, and allowed to stand. Moreover, the servings of cabbage salad ordinarily eaten by Maine people are small in comparison to the amounts mentioned above as necessary to provide two-thirds of the daily requirement of an individual.

The tomato juice used in this experiment was obtained from tomatoes of the Farthest North "C" variety (high in vitamin C) raised at Highmoor Farm by Iva M. Burgess. The juice was obtained by removing the stems and the imperfections from about 10 pounds of tomatoes, cutting the tomatoes in quarters and cooking them in an aluminum kettle until they were just soft. The cooked material then was strained immediately in an aluminum cone-shaped strainer, using a wooden cone-shaped pestle to speed up the process. After the juice obtained had been brought to the boiling point

quickly, it was poured into sterilized quart jars and the jars sealed. One teaspoonful of salt was put into the bottom of each jar before the juice was added.

Daily analyses of the tomato juice used during the experiment showed an average value of 20.7 milligrams of vitamin C per 100 cc. To secure two-thirds of a daily intake of 75 milligrams of the vitamin in the form of tomato juice it was necessary for the subjects to drink an average of 357.3 cc. of the juice (approximately 1½ of an ordinary size tumbler). The juice was given in two portions, one at breakfast and the other at dinner. Results showed that the vitamin C from the juice was as well utilized as was pure vitamin C in pill form. Since the above amount of tomato juice can be consumed easily at one meal by the average person and since the vitamin C in completely filled jars of this juice does not vary to any great extent after 40 days[8] it seems safe to say that tomato juice can be the major source of vitamin C in the diet, provided it is made by approved methods from tomatoes high in vitamin C.

Ascorbic Acid Content of Tomatoes and Cabbages as Influenced by Locality, Season, and Maturity. Four varieties of tomatoes were grown by Elizabeth Murphy at Aroostook Farm, Presque Isle; at Orono; at Highmoor Farm, Monmouth; and at Kennebunk during the 1938 and 1939 seasons.[9] It was found that seasonal variation is an important factor influencing the vitamin C content of tomatoes. In 1938 the ascorbic acid of Aroostook grown tomatoes was lower than that of tomatoes grown in the other three localities. In 1939, however, the ascorbic acid content of the Aroostook grown tomatoes, although lower than that in the tomatoes from Orono, was higher than for the other two localities.

That varieties vary in inherent ascorbic acid values is shown by the fact that Comet (a high variety) was significantly higher than Penn State Earliana (a low variety) in ascorbic acid in any one locality in the 1939 season. Analogous findings for the 1938 season showed the Comet variety to be vastly superior to the Penn State Earliana in ascorbic acid content. Small differences between

[8] The cause of loss of vitamin C from bottled tomato juice. D. K. Tressler and K. M. Curran. J. Home Ec. 30:487–488. 1938.

[9] Data published in an article entitled "The Ascorbic Acid Content of Different Varieties of Maine-Grown Tomatoes and Cabbages as Influenced by Locality, Season, and State of Maturity." Food Res. 6:489–502. 1942.

varieties, however, may be obscured by the effects of locality and season. Briefly it may be said that tomato varieties relatively high in ascorbic acid content can be made available. There may be some variation in the content from season to season or from one locality to another, but high value varieties in any season or locality are likely to be superior in this respect to low value varieties.

Cabbage varieties were grown in the same four localities, as mentioned above for tomatoes, during the 1939 season. The four varieties under test showed remarkable similarities in respect to ascorbic acid content. Cabbage grown in Aroostook County had a higher ascorbic acid content per gram than did cabbage grown at Orono, at Highmoor Farm, or at Kennebunk. This held for all varieties and for practically all testing periods except very early in the season. As the cabbages matured the ascorbic acid content declined. Therefore, young cabbage is a much better source of vitamin C than is fully matured cabbage. This may account for the higher values for the Aroostook grown cabbage since the season there is some later and the cabbage at any one testing period would be less mature than in the other three sections of the State.

New Varieties. In view of the comparative newness of the information on the role of vitamins in nutrition it is very likely that many of the commonly grown varieties of food crops are not as high in these nutritional values as may be desirable and possible to obtain. Numerous varieties of garden crops including peas, tomatoes, and sweet corn are being grown by W. Franklin Dove and Elizabeth Murphy. These various varieties are being subjected to analysis with a view to finding the best varieties for this area. One wild tomato variety, for instance, contained approximately 50 milligrams of vitamin C per 100 grams of tomato, which is about twice as high as is common in most of the commercial varieties. This particular variety apparently is of no commercial value since the fruit is extremely small and the flavor decidedly unsavory. It does, however, possess a value for possible improvement in tomato varieties in vitamin C content through appropriate plant breeding studies. Similarly, Farthest North "C," a selection made by Iva M. Burgess from the Farthest North variety obtained from North Dakota, has little value for commercial growing because of the small fruit size. In tests made by Elizabeth Murphy at Presque Isle and in the St. John Valley, however, this varietal selection proved to have exceptional values for the home garden. It ma-

tured fruit even in northern Aroostook County and the fruit was found by Miss Murphy to be very high in ascorbic acid content.

Many varieties of sweet corn have been tested by W. Franklin Dove for vitamin A content and for palatability. Two of the most promising varieties in this respect are Golden Bantam and Golden Cross Bantam which are, of the varieties tested, relatively high in Beta-carotene equivalent (vitamin A source). These two varieties, also, show considerable promise from the standpoint of palatability.

Other Studies Bearing on Nutrition. Farm orchards of apple varieties high in vitamin C are a possibility on the basis of the studies made by Merle T. Hilborn and discussed in the "Fruits Section" of this Report (Bul. 411). The Baldwin is a variety of promise in this respect since it ranks above the average in vitamin C content.[11] The Baldwin has suffered seriously from winter injury in past years although it has been a very popular variety with the consumer. The prospects are good, however, that this variety can be grown successfully in Maine if suitable hardy interstocks are used. Since many apples are eaten raw they could supply a considerable portion of the daily requirement of vitamin C.

The development of satisfactory methods for ensiling grass and clover for dairy animals could be extremely valuable from the human nutrition standpoint. It has been shown, for instance, that the vitamin A content of milk produced by dairy animals fed on grass silage in the winter months is practically as high as when the cows are on spring pasture.[12] The work by Delmar S. Fink in an effort to discover methods for satisfactorily ensiling grasses and clovers, therefore, has a bearing upon the subject of improvement in human nutrition. This study is continuing with some assurance that a practicable method will be developed.

REGIONAL NUTRITION LABORATORY

A Regional Laboratory for research into the relation of soils to plant, animal, and human nutrition was approved by the Secretary of Agriculture on January 31, 1939. This Laboratory is located at Ithaca, New York. Following is a brief report of the Director of the Laboratory, Doctor L. A. Maynard:

[11] Me. Agr. Exp. Sta. Bul. 397.

[12] Report on The Agr. Exp. Stations 1941, p. 81.

"In recent years interest has been aroused as to the effects on man and animals when plant or animal products from certain soil areas were used as food. In some cases physiological disorders common among man and animals in certain sections do not occur in other sections of the country. Some soils contain undesirable elements which inhibit the growth of plants and affect adversely the growth of animals. Knowledge of the number of mineral elements of biological significance has increased in recent years. At the same time, additional and important functions have been ascribed to some that long have been known to be essential. The role in nutrition of many of the so-called minor elements is not fully understood, and it is possible that there are other elements which have biological significance as yet unrecognized.

"The laboratory is attempting to determine the effect of mineral elements in the soil on the plants grown on them and the effect in turn on the animals and humans consuming the plants. While the function of the mineral elements in the normal nutrition of plants and animals is important, the effect of deficiencies of one or more of these elements is of equal or greater importance. Continued cropping has depleted soils in some areas of certain of the mineral elements. When these facts are known, it will be possible to replenish these elements through direct application of fertilizers containing them and through agricultural practices.

"Two seasons' work with several thousand tomato plants grown in sand cultures has indicated that neither the vitamin C nor the provitamin A content of the fruit is markedly affected by wide variations in the supply of such nutrient elements as calcium, potassium, magnesium, phosphorus, nitrogen, and sulfur. The ascorbic acid (vitamin C) content of the fruits varied considerably with the season. Fruits produced during the winter on hothouse plants had values approximately one-half those of summer-grown fruit. Plants grown in sand cultures supplied with balanced nutrient solutions produced fruit as high or higher in ascorbic acid than those obtained through the use of a good soil. There are also indications that relative length of day is one of the factors influencing ascorbic acid content. Fruit produced during long days had higher values than that produced during short days. Varietal differences and differences in climatic environmental conditions under which plants are grown probably have more influence on variations in the

vitamin value of tomatoes than variations in soil factors. The quantity of calcium in both fruit and vines could be increased by increasing the amount supplied to the plant. On the other hand, an increase in the potassium supply resulted in a decrease in the calcium, and an increase in the magnesium, content of the fruit. The laboratory also discovered that the amount and percentage of blossom-end rot in the fruit was inversely correlated with the relative amount of calcium in the nutrient solution.

"In an effort to evaluate the effect of mineral elements on the nutritive value of other vegetables, the laboratory grew turnip greens in various culture solutions and in two different soils. Analyses of the leaves indicated that their provitamin A content may be correlated closely with the growth vigor of the plants, those plants which grew most luxuriantly being richest in provitamin A. Cooperative studies with several experiment stations in the southeast and with the National Institute of Health have revealed significant differences in the cobalt content of turnip greens and other foods grown on different soils. These data show that spinach will accumulate more cobalt than turnip greens and that the leafy foods are generally higher in cobalt than are roots and seeds.

"Last year it was reported that the nitrogen content of both the kernel and stover of tetraploid (having twice the usual number of chromosomes) corn was higher than in the diploid (having the usual number of chromosomes) in certain strains. This study was extended to a number of red clovers in which the chromosomes had been doubled as in the corn. In this case no difference in the nitrogen content of the plants could be demonstrated. Apparently the chromosome number can have an influence on the nitrogen content of some plants, and thus on the nutritive value of the plants, but certainly no generalization can be made. In other words, a promising plant produced by changing the number of chromosomes will have to be analyzed to determine whether or not its nutritive value has been improved.

"The laboratory has continued to study methods for accurately and more rapidly evaluating the nutritive value of plants than is possible with existing methods. A rapid chemical procedure for the determination of provitamin A in the tomato fruit has been successfully completed. The fungus method for analysis for vita-

min B_1, reported last year, was used to determine variations in the vitamin B_1 content of wheat from various sources. The results indicated that the variations depended upon variety and growing conditions. Rapid progress is being made in the development of schemes of spectrographic and chemical analyses to correlate the contents of nutritionally important minerals and vitamins in plants and their products."

PUBLICATIONS

Following is a list of publications giving the results of research which may be of interest to those concerned with human nutrition problems. Any of these publications, except where noted, may be had free upon request by addressing the Experiment Station at Orono.

A Study of the Causes of Nutritional Deficiency Diseases in the Livestock and Inhabitants of Maine with Possible Corrective Methods Secured from the Utilization of Maine Fishery Products and the Production of Superior Foods. Me. Agr. Exp. Sta. Bul. 375.

Report of Progress for Year Ending June 30, 1941. Me. Agr. Exp. Sta. Bul. 405: pp. 431–458.

Report of Progress for Year Ending June 30, 1940. Me. Agr. Exp. Sta. Bul. 400: pp. 229–248.

The Ascorbic Acid Content of Different Varieties of Maine-Grown Tomatoes and Cabbages as Influenced by Locality, Season, and State of Maturity. Jour. Agr. Res. 64: 483–502, 1942. Reprint available from the Superintendent of Documents, Washington, D. C. at 5¢ per copy.

FARM CREDIT

FARM CREDIT IN MAINE. Charles H. Merchant. The revised manuscript on agricultural credit conditions in Aroostook County has been completed. The manuscript contains information on indebtedness of farmers, credit agencies and their policies, factors affecting ability of farmers to repay loans, and suggested improvements in the use of credit by farmers and in the making of loans by credit agencies.

FIELD CROPS

SMALL GRAIN VARIETY TEST. Joseph A. Chucka and Arthur Hawkins. *Barley.* Six varieties of barley (Byng, Alpha, Hannchen, Wisconsin 38, Oderbrucker, and Velvet) were included in the small grain variety test at Aroostook Farm. The 1941 yield ranged from 50.1 to 25.7 bushels per acre. The varieties ranked in yield in descending order as arranged above.

TABLE 1

Yields of Barley—Variety Trials—Aroostook Farm, Presque Isle, Maine—1932–1941
Bushels per acre

	1932	1933	1934	1935	1936	1937	1938[1]		1939[2]		1940		1941	1937-41 Average *	1938-41 Average *
							No fertilizer	Fertilized	No fertilizer	Fertilized	Early[4]	Late[5]			
Alpha	52.6	65.1	26.8	37.4	44.7	47.0	29.5	41.2	35.7	41.2	68.6	60.0	47.5	47.1	47.1
Byng						65.5	26.2	37.1	34.3	47.6	69.2	55.9	50.1	49.8	47.2
Hannchen							20.6		36.4	41.7	65.7	51.3	47.1		43.8
Manchurian						37.6									
Oderbrucker							20.2		26.0	35.2	51.2	38.9	25.9		32.9
Spartan						41.7	15.9								
Trebi						63.1	27.1	37.0							
Velvet	34.6	57.1	21.7	28.1	42.8	50.1	17.8	34.0	26.0	37.5	53.9	41.7	25.7	36.1	33.8
Wisconsin 6	36.7	53.6	23.2	33.3	49.5										
Wisconsin 38	39.4	62.2	19.0[3]	37.1	44.6	46.1	18.6		25.2	35.5	54.8	50.5	41.8	38.9	37.7
Min. difference for significance		15.7	3.0		9.9	8.9	3.8	9.4	5.1	5.9	7.2	7.8	4.3		

[1] Fertilized with 300 pounds 8-20-8.
[2] Fertilized with 300 pounds 8-16-20.
[3] Poor stand, thinly seeded.
[4] Planted May 14, 1940.
[5] Planted June 14, 1940.

* 1938 Fertilized not included in average yields.

A summary of the yield secured with the various varieties of barley grown at Aroostook Farm during the last ten years is given in Table 1. The two best yielding varieties are Alpha and Byng. Alpha is a two-row, rough awn barley while Byng is a six-row, smooth awn barley. The smooth awn varieties are handled with less discomfort than is experienced with the rough awn types.

Oats. Eleven varieties of oats (Eagle, Vanguard No. 7, Erban, Me. 340, Sovereign, Upright, Victory, Richland, Gopher, Vicland, and Lenroe) were included in the 1941 small grain variety test at Aroostook Farm. The varieties ranked in yield as arranged above in descending order and the yield range was from 72.6 to 45.3 bushels per acre.

A summary of the yields secured with the various varieties

TABLE 2

Yields of Oats—Variety Trials—Aroostook Farm, Presque Isle, Maine—1932–1941
Bushels per acre

	1932	1933	1934	1935	1936	1937	1938	1939	1940		1941	1937-41	1939-41
									Early[1]	Late[2]		Average	Average
EARLY													
Gopher	43.9	77.2	58.1	58.6	79.9	66.9	49.5	48.3	78.3	65.2	54.7	60.5	61.6
Richland									99.4	67.8	55.2		
Vicland											52.8		
MIDSEASON													
Cartier					64.3	46.7							
Cornelian	41.5	76.0	53.0	62.5	46.1	56.9							
Eagle						83.4	45.0	49.3	111.7	83.2	72.6	74.2	79.2
Erban								54.6	107.8	69.0	68.2		76.7
Iogold						[illegible]	45.4						
Ithacan						73.5	48.1						
Lanark					71.6	31.5							
Lenroe						69.8	45.9	42.3	88.9	46.2	45.3	56.4	55.7
Mabel					82.6	52.8							
Maine 340	50.2	82.0	51.7	58.4	69.3	66.4	48.1	52.9	88.8	63.7	60.7	63.4	66.5
Markton		68.0	55.8	—	55.4	62.1							
Minn. Smut Res.		58.1	55.6	40.1	65.4	68.6	47.9	42.0					
Rainbow						63.3	42.5						
Sovereign						79.9	46.5	49.0	108.0	72.7	60.2	60.4	72.5
Upright						72.7	48.8	39.0	99.5	64.9	55.7	63.4	64.8
Vanguard #7								54.[illegible]	102.5	68.3	69.2		72.2
Victory						83.3	43.7	43.8	79.6	68.9	55.4	62.5	61.9
Worthy	51.4	81.5	60.2	—	—								
Min. difference for significance		15.5	4.6	10.9	20.6	14.4	10.3	9.8	22.1	16.8	5.9		

[1] Planted May 14.
[2] Planted June 14.

of oats grown at Aroostook Farm during the last ten years is given in Table 2. Among the early maturing varieties Richland appears to be as good or better than Gopher. Among the midseason to late maturing varieties Eagle, Erban, Sovereign, and Vanguard No. 7 all appear to outyield Maine 340. Eagle is an especially good yielding variety of oats under Aroostook County conditions.

Wheat. Ten varieties of spring wheat (Rival, Premier, North Dakota No. 2822, North Dakota No. 2829, Sturgeon, Canadian No. 1005, Apex, Thatcher, Reward, and Garnet) were included in the 1941 small grain variety test at Aroostook Farm. The varieties ranked in yield as arranged above in descending order and the yield range was 21.1 to 5.3 bushels per acre.

A summary of the yields secured with the various varieties of wheat grown at Aroostook Farm during the last ten years is given in Table 3. Garnet wheat has been popular in Maine for many years and often produces high yields. However, in those years when stem rust is bad (1938 and 1941) such rust resistant varieties as Premier and Rival may be expected to produce higher yields.

TABLE 3

Yield of Wheat—Variety Trials—Aroostook Farm, Presque Isle, Maine—1932-1941
Bushels per acre

	1932	1933	1934	1935	1936	1937	1938	1939	1940		1941	1937-41	1939-41
									Early[1]	Late[2]		Average	Average
Apex							9.2	20.1	24.8	27.5	13.9		21.6
Ceres				18.1	15.1	31.4	2.9						
Garnet	20.3	39.5	17.6	17.7	20.1	35.7	5.1	16.8	30.9	29.0	5.3	20.5	20.5
Marquis	8.6	33.0	10.9	16.8	9.9	26.6	1.7						
Mercury								2[illegible]2					
Premier								25.2	24.9	30.0	20.0		25.0
Red Fife	10.0	32.4	10.8	18.5	8.8								
Reward				14.8	12.5	31.5	9.1	17.5	27.5	24.6	11.0	20.2	20.2
Rival								24.0	18.9	25.6	21.1		22.4
Sarton							3.7	15.6					
Sturgeon						32.7	8.5	20.0	26.4	25.7	17.0	21.7	22.3
Thatcher				12.1	7.8		6.3	16.6	23.7	25.1	13.9		19.8
R.L. 1005						32.9	10.4	20.1	25.5	26.9	16.6	22.1	22.3
Ns 2809									20.4				
Ns 2822									25.4		20.0		
Ns 2829									27.9		19.6		
Min. difference for significance					3.5	3.9	—	2.8	3.8	5.0	1.7		

[1] Planted May 14.
[2] Planted June 14.

FORESTRY

FOREST PATHOLOGY. M. T. Hilborn. Numerous white pine trees on the Forestry Preserve at Orono are affected with an unknown canker. Field studies in the spring of 1941 indicated that this disease is prevalent throughout the white pine stands of Maine. Trees in southwestern Maine are severely diseased in some locations, and the disease has been found also in central and northeastern Maine. Fruiting bodies of several fungi have been found to be associated with the cankered portions of the trees. *Dasyscypha agassizii* (B. & C.) Curt. occurs on the old cankered bark, but is apparently acting as a saprophyte on the dead tissues. *Septobasidium pinicola* Snell is often found on the affected pine trees, but this organism is commonly found on trees and is not considered to be the cause of any significant injury. *Caliciopsis pinea* Peck is the most common fungus found in association with the cankered portions of affected trees. This fungus is known to be a pathogene capable of causing considerable injury to individual trees. Past experience, however, indicates that this fungus is found only on trees of reduced vigor, and the organism is usually considered as being an indicator of a tree that has been weakened by some other cause. Field observations to date in Maine indicate that many cankered trees are not low in vigor, but had made good growth previous to the appearance of the canker. Further studies are being made on the relationship of *Caliciopsis pinea* to this canker of white pine trees in Maine.

A study was made on *Fomes fomentarius* a fungus disease of hardwood trees particularly. In Maine this disease was found mostly on the species of birch and on beech. Field studies on infected trees showed that the fungus causes a typical, white mottled rot in the heartwood and sapwood of both living and dead trees. In dead trees the organism apparently attacks the sapwood and heartwood simultaneously. In living trees the heartwood is decayed first, and then the adjacent sapwood. There is considerable loss in fuel value of wood due to the attack of this fungus. The details of this more or less technical study are published in Station Bulletin 409.

LAND UTILIZATION

LAND USE STUDIES—SOIL SURVEY. Joseph A. Chucka, Delmar B. Lovejoy and John R. Arno in cooperation with Kenneth V. Goodman of the Soil Survey Division, Bureau of Plant Industry and S. Von Day of the Soil Conservation Service, United States Department of Agriculture. Field work in the classification and mapping of soils was conducted in Penobscot County during the past year. A report on the soils of Waldo County is in the process of preparation and will soon be ready for the printers.

LAND USE ECONOMICS. Andrew E. Watson. The land classification work was continued during the past year in Penobscot County. Information was collected in twenty towns. The objectives of this study were the same and the procedure used was essentially similar to that used in 1940. The Penobscot County data are now being summarized. Further work in Penobscot County will be discontinued until the Soil Survey has had an opportunity to complete its phase of the study in the towns where the land use material has been procured. A detailed soil map of York County has been prepared and land classification work is under way in the County. Aerial photographs obtained for the entire County will aid in the work.

Information on 31 towns in Aroostook County is available in Station Bulletin No. 413.

SOIL TESTING SERVICE. D. S. Fink and J. W. Cyr. The Experiment Station has analyzed to date some 16,000 soil samples for available plant food and acidity. A number of special studies are associated with this testing work. This past year, samples of potato tops prior to burning were obtained by Arthur Hawkins. These samples were analyzed and the return of plant food to the soil, in the form of ash, was calculated as shown in Table 4. It is clear from this information that the usual practice of burning potato tops markedly affects the acidity and the available plant food content of the soil on areas where potato tops are burned. This in turn makes it difficult if not impossible to obtain a truly representative soil sample of a potato field.

The effect of including in a composite soil sample areas where potato tops were burned was studied by J. W. Cyr. Thirteen areas in each of four fields were sampled separately. Samples were

taken, on the row, in an area where tops were burned and also immediately outside this area where tops were not burned. The average values for pH and available plant food content of the soil taken on each of the four fields where potato tops were not burned, as well as where tops were burned are given in Table 5. The increase in pH value and available phosphorus, potassium, calcium and magnesium of the soil taken where potato tops had been burned is very striking.

TABLE 4

Amount of Plant Nutrients in Field Raked Green Mountain Potato Tops (Coarse Stems Only). Raked October 20, 1941

Plant nutrient	1000 lbs. tops contain	When raked, piled and burned—concentrated 100 times (About 20 piles per acre)	
		Area on which burned Lbs. per acre rate	Lbs. per acre calcium carbonate equivalent
	Lbs.		
Nitrogen (N)	10.0	Lost	
Phosphoric acid (P_2O_5)	3.3	330	– 626
Potash (K_2O)	8.6	860	912
Calcium oxide (CaO)	21.8	2180	3890
Magnesium oxide (MgO)	4.7	470	1164
			Total 5340
Neutralizing power equal to applying on the area where tops are burned about—			6000 lbs. ground limestone per acre

TABLE 5

A Comparison, on Four Potato Fields, Showing for Each Field the Analysis of Soil from the Field Proper Versus Areas Where Potato Tops were Burned. Each Analysis is the Average Values of Thirteen Samples Taken in the Row

Field No.	Composite of thirteen samples	pH	NO_3	NH_3	P	K	Ca	Mg	Mn	Fe	Al
1	Field proper	5.23	17	5	62	104	1154	31	47	7	96
	Potato tops burned	6.64	17	6	212	338	3154	79	41	17	181
2	Field proper	5.15	18	5	80	90	1850	45	19	10	84
	Potato tops burned	6.37	26	14	200	140	3100	85	60	10	84
3	Field proper	5.13	11	5	65	165	1000	38	12	12	100
	Potato tops burned	6.44	12	8	150	290	2900	63	31	13	115
4	Field proper	4.80	12	5	69	77	770	31	15	13	100
	Potato tops burned	5.85	15	9	136	195	1704	61	21	14	100

Note: Values reported are in pounds per acre.

Various composite mixtures were made of the twenty-six individual samples from field No. 1, Table 5. Each composite sample represents thirteen areas of the field. Composite sample No. 1 (see Table 6) represents the field proper, or thirteen areas where tops had not been burned. Composite sample No. 2 includes twelve areas where potato tops had not been burned and one area where tops had been burned, while composite sample No. 3 includes 11 and 2, respectively, etc.

The data in Table 6 show that the pH value of field No. 1 is optimum for growing potatoes, namely, 5.30 when sampled by taking thirteen borings where tops had been burned. If, however, the composite sample includes twelve borings taken where tops had not been burned and only one boring taken where tops were burned, the pH immediately shows an increase from 5.30 to 5.68. Large increases in phosphorus, potash, calcium, and to a limited extent magnesium, also result.

TABLE 6

The Effect on Soil Analysis of Including, in a Composite Field Sample of Thirteen Borings, One or More Borings of Soil from Areas Where Potato Tops were Burned

Composite samples	No. of samples field proper	No. of samples potato tops burned	Total acres	pH	NO_3	NH_3	P	K	Ca	Mg	Mn	Fe	Al
1	13	0	13	5.30	10	5	50	100	1000	25	50	5	100
2	12	1	13	5.68	20	5	100	200	1500	50	50	5	100
3	11	2	13	5.91	10	5	100	300	2000	50	50	5	100
4	10	3	13	6.09	10	5	100	300	2000	50	50	5	100
5	9	4	13	6.11	20	5	200	300	3000	50	50	5	100
6	8	5	13	6.27	10	5	200	excess	3000	50	50	5	100
7	7	6	13	6.30	20	5	200	excess	3000	50	50	5	100
8	6	7	13	6.29	20	5	200	excess	excess	50	50	5	100

Note: Values reported are in pounds per acre.

This study clearly shows the necessity of avoiding areas where potato tops have been recently burned if one is to obtain a representative soil sample of a potato field.

INSPECTION SERVICE

The Commissioner of Agriculture is the executive of the laws regulating the sale of fertilizers, agricultural seeds, insecticides, fungicides, foods, drugs, and feeding stuffs in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to analyze or cause to be analyzed the samples collected by the Commissioner and to publish the results of the analyses together with the names of the persons from whom the samples were obtained and such additional information as may seem advisable. This information is reported in the Official Inspections published during the year. The State Tax Assessor is the executive of the laws regulating the sale of gasoline and motor lubricants. It is the duty of the Director of the Station to analyze or cause to be analyzed the samples collected by the State Tax Assessor but no provision has been made for the publication of the results of the analyses.

In addition to the inspection service the department is requested frequently to make analyses of various types of materials for individuals. These unofficial samples include milk, cream, vinegar, miscellaneous substances, and materials suspected to contain poison. The results of the analyses on these samples are not published but are reported to the individuals who submit the samples. Elmer R. Tobey, C. Harry White, Bernie E. Plummer, Jr., Millard G. Moore, *Edward O. Merrill, A. Stanley Getchell, *C. Byron Sibley, *John S. Getchell, and George P. Steinbauer.

Testing of Dairy Glassware. It is required by law that all Babcock glassware used in Maine by creameries, ice cream factories or others buying or selling milk or cream on a basis of the butterfat content must be tested for accuracy at the Maine Agricultural Experiment Station. One thousand one hundred eighty-nine pieces have been examined. Six pieces were not passed.

Fertilizers. Four hundred fifty-nine samples of fertilizer materials were collected and analyzed. Three hundred forty-eight of these samples were mixed fertilizers containing nitrogen, phosphoric acid, potash, and in some of the samples, magnesium. One sample was guaranteed to contain borax. The samples of mixed fertilizers represented two hundred fifty-four different brands.

* On leave of absence, Military service.

Of the total number of samples received eighty-one were found to be below guaranty in total nitrogen, one hundred six in available phosphoric acid, twenty-nine in total phosphoric acid, sixty-five in water soluble potash, three in water soluble magesium, seven in total magnesium and four in total calcium oxide. The results of the analyses are reported in Official Inspections 181.

Agricultural Seeds. Fungicides and Insecticides. Two hundred six official samples of seeds and seventy-seven official samples of fungicides and insecticides were collected and analyzed. The majority of the seed samples tested showed close agreement between the per cent of germination and per cent purity as given on the label and as found in the laboratory. The greatest differences between the guaranties on the label and results obtained in the laboratory were relative to the noxious weed seed content. In several instances a large number of noxious weed seeds were found per pound of seed but were not reported on the label. The results of analyses on the samples of fungicides and insecticides showed twenty-four deficiencies in respect to guaranties. The results of the analyses are reported in Official Inspections 182.

Foods and Drugs. The number and variety of samples collected and submitted depend upon the nature of the inspection work carried on by the Division of Inspection, Augusta, Maine, in the enforcement of the food and drug laws. A total number of five hundred eighty-seven samples, which consisted of carbonated beverages, canned crab meat, ice cream, oil used in packing sardines, olive oil, shucked clams, aspirin, diluted hydrochloric acid, solution of magnesium citrate, spirit of camphor, spirit of peppermint, and sweet spirit of nitre, have been examined and the results of the analyses are reported in Official Inspections 183. In the majority of cases these results showed no great variations from the respective standards or guaranties with the exception of the results on seven samples of olive oil. Four of these samples were adulterated with cottonseed oil. The other three samples consisted in whole or in part of an oil other than olive oil.

Bacteriological Work. The amount of work carried on in the bacteriological laboratory has increased approximately one thousand samples over last year. A total of six thousand seven hundred seventy samples have been examined. Of this number, four thousand one hundred seventy-five were milk and cream, two

thousand sixty-three were examinations of drinking utensils, the remaining number includes fifty-eight samples of sea water, one hundred thirty-eight samples of shellfish, and three hundred thirty-six miscellaneous samples which have been examined for municipal departments of health and private individuals. The results of the analyses, reported in the food and drug Official Inspections 183, showed that seven samples of milk were adulterated by the addition of water. The examinations of drinking utensils indicated a definite improvement in most cases over the preceding year in bacteria count. Practically no change was noted in the scores obtained in the periodic examination of shellfish as compared with the previous year.

Feeding Stuffs. Six hundred thirty-three samples of feeding stuffs were received and the percentages of protein, fat, and fiber in these samples were determined. The results of the analyses are published in Official Inspections 184.

Gasoline. Two hundred seventy-five samples of gasoline were received. The results of the analyses indicated that none of these samples were found to require a higher temperature for complete distillation than the maximum temperature (437° F.) specified in the Maine law regulating the sale of motor gasoline.

Motor Lubricants. Seven of the thirty-five samples of motor oils which were examined failed to meet the specifications for the respective brands asked for by the inspector. In nearly every instance it appeared to be a case of substitution by the salesman. One sample contained water and dirt. One sample contained a small amount of material with a low flash point such as kerosene or gasoline.

FAMILY ECONOMICS

HOUSEHOLD EQUIPMENT. Merna M. Monroe and Pearl S. Greene. *The Effect of the Method of Heat Application, and Accompanying Oven Conditions, upon the Flavor and Texture of Baked Foods.* As mentioned in previous reports, steam in the oven atmosphere does not prevent browning of batters and doughs when other baking conditions are similar. The lack of browning obtained by homemakers when batters are baked at the same time

as watery foods is due to insufficient heat reaching the batters in spite of a constant thermostat setting. Pans of watery foods absorb a large amount of heat while being raised to the boiling temperature and during the vaporization of the water at the surface of such foods. Also, the presence of the pans obstructs circulation of heat which normally tends to equalize temperatures at various parts of the oven with those at the thermostat bulb.

The work concerned with the effects on baking when steam is added to the oven leads to the following conclusions: (1) The effect of steam is that which occurs during the first few minutes of baking. The steam condenses on the pan and on the exposed surface of food and gives a faster rate of heating. The condensation dries off when the outer portion of the food has been heated above the dewpoint temperature. After the material has been heated beyond the dewpoint temperature, the steam in the oven has no further effect. (2) The thermal conductivity and capacity of the food affect the amount of condensation which occurs. The food which is a good thermal conductor causes more condensation of the steam than a food which is a poor conductor. The greater the condensation of steam on the pan and food, the greater is the effect on rate of rise in temperature of the food as compared with baking done without steam added to the oven. (3) Given the same amount of steam in the oven at various baking temperatures, the steam has a greater effect on rate of heating when the oven is maintained at moderately low than at relatively high oven temperatures. The higher oven temperature permits faster heating of the food so that there is less time for condensation of steam. The same characteristic was observed when the heating was done in a glass casserole and in a black sheet-iron loaf pan. The black loaf pan gave faster initial heating than did the glass casserole; the steam had less effect on the rate of heating in the black pan than it did in the glass casserole. Under household conditions the steam would be formed from watery foods cooked in the oven; therefore, it is unlikely that equal amounts of steam would be present at moderately low and high oven temperatures because the rate of evaporation from uncovered foods would be greater for the high than for the low oven temperatures.

Since electric-range ovens do not have sufficient ventilation

to free the oven of excess steam, the method of venting was studied. This was done by heating a pan of water and estimating the approximate dewpoint temperature by noting the temperature of the water when the fine dew dried off from the outside of the pan. The dewpoint temperature is a measure of the absolute amount of steam in the oven. Steam was fed to the oven at a moderate rate to give a dewpoint temperature approximately equal to that obtained by heating three uncovered pans of water at 425° F. Under these conditions of testing, the dewpoint temperature was 171° F. when the vents were closed; 164° when the top rear vent was opened; 149° when holes in the bottom of the oven were opened; and 129° when both bottom and top-rear vents were opened.

Although steam does not prevent browning and does frequently hasten the rate of heating of the food during the first part of baking, yet the presence of steam sometimes has a deleterious effect on the top-crust of batters. With ordinary top rear venting of the electric oven, the muffins split when steam as such was fed to the oven or when the steam was formed from uncovered pans of water heated in the oven prior to and during baking. The muffins did not split if venting was at the bottom of the oven where incoming cold air would hasten circulation. As given in the above paragraph, the bottom venting reduced the dewpoint temperature to a greater extent than did top rear venting. This suggests that bottom venting of electric ovens may be an improvement in design.

In the electric range of present design, muffins will split on top and biscuits may separate when baked during the latter part of cooking an oven meal of high water content. Opening the oven door for a long period to allow accumulated steam to escape may not prevent the splitting if the watery foods remain in the oven and continue to give off steam at a relatively fast rate.

A Study of the Performance of Wood Ranges Heated by Distillate Burners and an Evaluation of Factors Which Affect Their Performance. The work on these stoves has been completed and manuscripts written for a technical and for a popular report.

ANNOUNCEMENTS

Leave of absence was granted to Joseph L. Harrington, the leave to begin November 1, 1941, to permit military service.

Mr. Charles L. Hovey was appointed Assistant in Plant Pathology, the appointment effective April 1, 1942. Mr. Hovey is a graduate of Iowa State College, has the Master's degree from Oklahoma A. & M., and has practically completed the requirements for the Ph.D degree at the University of Minnesota. He will specialize in the study of insect-borne diseases of potatoes.

Dr. Stanislas F. Snieszko who was employed by the Station on a one-quarter time basis for the year 1941-42 has been employed for 1942-43 on a three-quarter time basis. Dr. Snieszko will conduct research on Bacterial Ring Rot in potatoes.

The construction of the two range greenhouse and head house at Aroostook Farm was completed about January 1, 1942, and is now in use. This greenhouse is being used very effectively in the research program with potato diseases. The costs of construction and operation of this greenhouse are defrayed from Potato Tax funds.

PUBLICATIONS

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station and in scientific journals, both foreign and domestic. The bulletins for the year, including this Report of Progress, make up the complete annual report. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and may be bound with the annual report as an appendix thereto. Miscellaneous publications, consisting of newspaper notices of bulletins and newspaper articles which are not paged consecutively and for the most part are not included in the annual report, also are issued during the year. A new practice was initiated this year for the Progress Report which is Station Bulletin No. 411. The complete Report is being printed as usual, but for distribution within the State separates have been prepared for various subject matter fields. Those desiring only the report

on Potatoes, for instance, may obtain this by requesting Bulletin 411-C. The separate for Fruits Research is 411-A; for Canning and Garden Crops, 411-B; for Dairying, 411-D; for Poultry Research, 411-E; and for Foods and Nutrition, 411-F.

BULLETINS ISSUED IN 1941-1942

No. 406. Farm Organization and Costs and Returns in Producing Potatoes on Farms in the St. John River Area of Aroostook County, Maine, 1937.

No. 407. Results of Testing Some Laboratory Methods for Possible Use in the Detection of Virus Diseases in Potato Tubers.

No. 408. Farm Management on Central Maine Farms with Dairy Enterprises.

No. 409. The Biology of *Fomes Fomentarius.*

No. 410. Potato Virus Disease Studies with Tuber-Line Seed Plots and Insects in Maine, 1927 to 1938.

No. 411. Report of Progress for the Year Ending June 30, 1942. Separates from Report of Progress, Bul. 411:

411-A Fruits Research
411-B Canning and Garden Crops
411-C Potatoes
411-D Dairying Research
411-E Poultry Research
411-F Foods and Nutrition.

OFFICIAL INSPECTIONS ISSUED IN 1941-1942

No. 180. Commercial Feeding Stuffs, 1940–1941.

No. 181. Commercial Fertilizers, 1941.

No. 182. Commercial Agricultural Seeds, 1941, and Fungicides and Insecticides, 1941.

No. 183. Foods and Drugs, 1941–1942.

MISCELLANEOUS PUBLICATIONS ISSUED IN 1941-1942

No. 566. List of Available Publications.

No. 567. A Roguing Service for Producers of Foundation Seed Potatoes.

No. 568. Potato-harvest Labor in Aroostook County, Maine, 1941.

No. 569. Selling and Shipping Maine Potatoes.

LIST OF AVAILABLE PUBLICATIONS

No. 270. Some Eastern Aphids.

No. 272. Inheritance Studies of Color and Horn Characteristics.

No. 273. The Biology of Maine Species of Altica.
No. 279. The Variation of the Milk of Ayrshire Cows in Quantity and Fat Content of their Milk.
No. 285. Wheat Investigations I. Pure Lines.
No. 286. The Variation of Milk Secretion with Age in Jersey Cattle.
No. 289. The Correlation Between Milk Yield of One Lactation and that of Succeeding Lactations.
No. 290. The Variation of Butterfat Percentage with Age in Jersey Cattle.
No. 291. The Correlation between the Butterfat Percentage of One Lactation and Succeeding Lactations in Jersey Cattle.
No. 293. Studies in Milk Secretion. VIII. Influence of Age on Milk and Butterfat Yield in Holstein-Friesian Cattle.
No. 296. The Orthoptera of Maine. (Grasshoppers and Allied Insects.)
No. 306. Studies in Milk Secretion. XVII. Relation between Milk Yields and Butterfat Percentages of the 7-day and 365-day Tests of Holstein-Friesian Advanced Registry Cattle.
No. 311. The Effect of Age on the Milk Yields and Butterfat Percentages of Guernsey Advanced Registry Cattle.
No. 314. Studies on Conformation in Relation to Milk Producing Capacity in Cattle. III. Conformation and Milk Yield in the Light of the Personal Equation of the Dairy Cattle Judge.
No. 318. Interpretation of Dairy Pedigrees.
No. 320. The Influence of Ultra-Violet Light on Nutrition in Poultry.
No. 324. Studies in Milk Secretion. XV. Guernsey Sire's Progeny Performance for Milk Yield, Butterfat Percentage, and Butterfat.
No. 327. Studies in Milk Secretion. XVI. Progeny Performance of Guernsey Sires' Sons.
No. 329. Studies in Milk Secretion. XVII. Transmitting Qualities of Guernsey Sires for Milk Yield, Butterfat Percentage and Butterfat.
No. 330. Varieties of Ensilage Corn for Maine.
No. 332. Sweet-corn Breeding Experiments.
No. 339. An Economic Survey of the Apple Industry in Maine.
No. 341. Productivity of Guernsey Cows of American or Island Origin.
No. 344. Bud and Root Selection in the Apple.
No. 347. An Economic Study of 93 Apple Farms in Oxford County, Maine, 1924–1927.
No. 348. Apple Spraying Experiments in 1926–1927.
No. 351. An Economic Study of 239 Blueberry Farms in Washington and Hancock Counties, Maine.
No. 358. Comparison of Apparently Healthy Strains and Tuber Lines of Potatoes.
No. 364. Prices on Farm Products in Maine.
No. 365. The Effect of Handling Methods on Quality of Maine Potatoes.
No. 366. Farm-Property Taxation in Maine.

No. 367. An Economic Study of the Production and Utilization of Milk in Maine.
No. 368. Apple Spraying and Dusting Experiments 1928 to 1932 in Relation to Scab, Yield, and Tree Growth.
No. 370. Isolated Tuber-Unit Seed Plots for the Control of Potato Virus Diseases and Blackleg in Northern Maine.
No. 371. A Study of Factors of Economy in Electrical Cooking of a Typical Day's Meals in Maine.
No. 372. A Survey of the Cooking Practices in Maine Rural and Village Households.
No. 373. An Economic Study of the Collection of Milk and Cream in Maine.
No. 374. Costs and Returns in Operating Milk and Cream Collection Routes in Maine.
No. 375. A Study of the Causes of Nutritional Deficiency Diseases in the Livestock and Inhabitants of Maine with Possible Corrective Methods Secured from the Utilization of Maine Fishery Products and the Production of Superior Foods.
No. 378. A Study of the Organization and Management of Potato Farms in Aroostook County, Maine.
No. 379. A Study of the Organization and Management of Potato Farms in Central Maine.
No. 381. The Bionomics and Control of Wireworms in Maine.
No. 383. Factors Affecting the Cooking Qualities of Potatoes.
No. 385. An Economic Study of Milk Production Costs in Herds of Producer-Distributors in Maine.
No. 386. Evaluation of Certain Factors Affecting the Cost of Using Utensils on Electric Heating Units.
No. 388. A Histological Evaluation of Low Temperature Injury to Apple Trees.
No. 389. Biological Studies of Maine Moths by Light Trap Methods.
No. 390. Costs and Returns in Producing Potatoes in Aroostook County, Maine.
No. 392. Costs and Returns in Producing Potatoes in Central Maine.
No. 393. Food-Plant Catalogue of the Aphids of the World. Including the Phylloxeridae.
No. 394. Performance Analysis of Selected Types of Kerosene Stoves.
No. 395. An Economic Study of Milk Distribution in Maine Markets.
No. 396. Bacterial Wilt and Soft Rot of the Potato in Maine.
No. 397. Report of Progress for Year Ending June 30, 1939.
No. 398. The Organization and Management of 95 Dairy and Cash Crop Farms in Androscoggin and Oxford Counties, Maine.
No. 399. Receipts, Utilization, and Prices of Milk and Cream in Maine Milk Control Areas.
No. 400. Report of Progress for Year Ending June 30, 1940.
No. 402. Boron Deficiency Symptoms in Some Plants of the Cabbage Family.

No. 403. Aphids and Their Relation to the Field Transmission of Potato Virus Diseases in Northeastern Maine.

No. 404. Mineral Nutrition of the Genus *Brassica* with Particular Reference to Boron.

No. 405. Report of Progress for Year Ending June 30, 1941.

No. 406. Farm Organization and Costs and Returns in Producing Potatoes on Farms in the St. John River Area of Aroostook County, Maine, 1937.

No. 407. Results of Testing Some Laboratory Methods for Possible Use in the Detection of Virus Diseases in Potato Tubers.

No. 408. Farm Management on Central Maine Farms with Dairy Enterprises.

No. 409. The Biology of *Fomes Fomentarius.*

No. 410. Potato Virus Disease Studies with Tuber-Line Seed Plots and Insects in Maine 1927 to 1938.

No. 411. Report of Progress for Year Ending June 30, 1942. Separates for distribution within the State are available from Bulletin 411 for those interested in particular phases of the research. These are as follows:

411–A Fruits Research
411–B Canning and Garden Crops
411–C Potatoes
411–D Dairying Research
411–E Poultry Research
411–F Foods and Nutrition

No. 412. Egg Production in Maine.

No. 413. A Study of Land Use in Thirty-one Towns in Aroostook County, Maine.

Misc. No. 482. Aphid Galls of the Poplar.

Misc. No. 560. 1939 Vegetable Variety Trials and List of Recommended Varieties.

Misc. No. 561. Marketing Maine Potatoes. I. A Preliminary Report of Consumer Preference for Potatoes in Boston, March 4 to April 6, 1940.

Misc. No. 563. Marketing Maine Potatoes. A Preliminary Report on Inter-regional Competition of Maine Potatoes on the Botson Market.

Current numbers of Official Inspections, containing results of analyses on foods and drugs, commercial feeding stuffs, commercial fertilizers, commercial agricultural seeds and insecticides and fungicides, are available.

Any of these available publications will be sent free upon request. Also, upon request the name of any resident of Maine will be added to the Station's general mailing list. Persons whose

names appear on this list will receive during the year cards giving a summary of bulletins printed and copies will be furnished on request to those interested. The Station is unable to place the name of non-residents of Maine upon its general mailing list. We no longer send our publications regularly to non-residents, except in the case of libraries, exchanges, and agricultural investigators. Teachers, county agents, and others can obtain from the Office of Experiment Stations, Washington, D. C., a monthly list of the publications recently issued by the various experiment stations. In response to a definite request, single copies of the publications of this Station, that are included in the above list, will be sent to any address as long as the supply lasts.

ABSTRACTS OF PAPERS PUBLISHED BY THE STATION IN 1941-1942 BUT NOT INCLUDED IN THE BULLETINS

The following pages contain abstracts of papers published during the year 1941-42 in various scientific periodicals.

SOME RELATIONS BETWEEN MERCURIC CHLORIDE CONTENT, ACID CONTENT, AND FUNGICIDAL EFFICIENCY OF CERTAIN SOLUTIONS AS USED FOR POTATO-TUBER DISINFECTION[1]

Serious potato-crop losses are caused by Rhizoctonia. These losses can be reduced by seed disinfection which, however, is too time-consuming and requires renewing of the solution too often when performed with the standard cold 1-1000 corrosive sublimate. The solution when made acid with hydrochloric acid or acetic acid remains effective for 25 successive treatments instead of for only 5 or 6, and is effective in 5- to 10-minute treatments. The acetic acid is less injurious to skin and clothing. Seed treatment injury to tubers can be avoided by drying the tubers soon after treatment. Acidulation reduced the turbidity of the solution considerably. The acid was depleted more rapidly than the sublimate.

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[1] This is an abstract of a paper by Bernie E. Plummer, Jr., and Reiner Bonde, having the same title and published in Phytopath. 31: 812–817. 1941.

The Effect of Mulch on Soil Moisture, Soil Temperature, and Growth of Blueberry Plants[2]

High-bush blueberries were grown at Highmoor Farm on a sandy loam, at Cherryfield on a clay loam, and at Deblois on a very sandy soil to study the effect of mulch on soil moisture, soil temperature, and the growth of plants. Soil moisture was measured with tensiometers 6 and 12 inches below the surface. Soil temperatures were measured with thermometers, the bulbs being placed 6 inches below the surface. The linear growth of the plants was used as a criterion of growth.

Mulch increased soil moisture and lowered the soil temperature significantly. The growth of blueberries in the mulch plots on the sandy and sandy loam soils was less than in clean cultivation. However, in the clay loam plants grew more in the mulch than in clean cultivation.

Blueberry Storage[3]

Storage studies with blueberries in 1941 showed a great variation in the keeping quality of the different clones of low-bush blueberries and varieties of high-bush blueberries. The berries were stored at 41° F. in an atmosphere with an oxygen content of 5 per cent or slightly less and carbon dioxide content of 10 to 15 per cent. Commercially berries may be stored 2 to 4 weeks and they may be stored in the home refrigerator for several months.

Russeting of Golden Delicious Apples[4]

In 1936 scions were taken from trees which had a low amount of russeting in 1925 and grafted onto high russeting trees and low russeting trees; also scions from high russeting trees were grafted

[2] This is an abstract of a paper by F. B. Chandler and I. C. Mason having the same title and published in Amer. Soc. Hort. Sci. 40: 335–337. 1941.

[3] This is an abstract of a paper by F. B. Chandler having the same title and published in Science 95: 603–604. 1942.

[4] This is an abstract of a paper by F. B. Chandler and I. C. Mason, having the same title and published in Amer. Soc. Hort. Sci. 40: 120–122. 1941.

onto low and high russeting trees. In 1937 a number of trees were treated with boron. Analysis of the data indicates that in some years climatic or other factors cause a high percentage of russeting on all trees while in other years bud mutation, interstock, rootstock, and/or soil are more important than climate. From these studies it appears that russeting of Golden Delicious apples probably is sometimes caused by one or more of the following: (1) bud mutation, (2) one or more of the factors interstock, rootstock, and soil, and (3) a range of weekly precipitation with a maximum not in excess of two inches during the period of July 3 to July 28.

THE ASCORBIC ACID (VITAMIN C) CONTENT OF ONIONS AND OBSERVATIONS ON ITS DISTRIBUTION[5]

The ascorbic acid content of 16 varieties of Maine-grown freshly harvested onions varied from 0.17 mg. per gram for the Crystal White Wax variety to 0.40 mg. per gram for the Early Red Globe variety as determined by the chemical titrimetric method developed by Bessey and King.[6] These values were based on six or seven analyses executed over a period of seven weeks and thus include values for both immature and mature onion bulbs. The values for the large mature onions of nine varieties (the other six did not mature during the season) ranged from 0.13 mg. per gram for Ebenezer to 0.22 mg. per gram for Southport Red Globe.

Small, immature onions were found to contain from 32 to 141 per cent more ascorbic acid than large onions of the same variety.

The central leaves of the onion bulb have a much higher concentration of ascorbic acid than have the peripheral storage leaves. The values for the outer fleshy leaves are from 14 to 59 per cent as large as are those for the central leaves. The outer leaves vary slightly whereas the inner leaves exhibit large differences between varieties. It seems that variations in the content of these young central leaves are chiefly responsible for varietal differences.

Losses varying in magnitude from 47 to 80 per cent of the

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[5] This is an abstract of a paper by Elizabeth Murphy having the same title and published in Food Research 6(6): 581–594. 1942.

[6] Bessey, O. A. and King, C. G. 1933. The distribution of vitamin C in plant and animal tissues, and its determination. J. Biol. Chem. 103: 687–698. 1933.

original values for fresh raw onions occur during storage under home conditions.

Losses during cooking range from 10 to 65 per cent dependent upon the time factor if the amount of cooking water remains constant.

In the fresh raw state, onions compare very favorably with the foods that are considered excellent sources of vitamin C, showing values as high as ripe tomatoes grown in the same locality.[7] Especially is this true when onions are immature. During the winter months, however, it would be unwise to depend upon the onion as a primary source of this essential food factor.

The determination of optimum storage conditions and the adaptation of these for home use might facilitate the retention of a large percentage of the original ascorbic acid content of fresh onions.

More frequent use of young raw onions in soups and salads would provide a valuable adjunct to a vitamin C poor diet.

GEOGRAPHICAL SITUATION AS AN INFLUENCING FACTOR IN THE PRODUCTION OF ASCORBIC ACID (VITAMIN C)[8]

Four varieties of tomatoes were grown during 1938 and 1939 and four varieties of cabbages were grown during 1939 in four widely separated localities in the State of Maine to determine the effect of geographical situation upon the production of vitamin C.

The tomato varieties chosen were Penn State Earliana, Bestal, Best of All, and Comet. From preliminary tests, the two former, were relatively low in ascorbic acid whereas the two latter varieties were at the upper end of the scale.

In 1938, it was observed that the tomatoes grown in Aroostook were lower in ascorbic acid content than those produced in the three more southern localities. The majority of the samples from Orono, Highmoor, and Kennebunk were over 0.06 mg. per gm. greater in vitamin C content than those from Aroostook.

In 1939, the observations were continued with the experimental procedure unchanged. The tomatoes produced in Aroostook were

[7] Murphy, Elizabeth. Unpublished data.

[8] This is an abstract of a paper by Elizabeth Murphy having the same title and published in Jour. Agri. Res. 64(9) : 483–502. 1942.

lower in ascorbic acid than those grown in Orono but higher than those grown at Highmoor and Kennebunk. The majority of the samples were more than 0.04 mg. per gm. higher in ascorbic acid content in Aroostook, Orono, and Highmoor than in Kennebunk.

An analogous experiment in which four varieties of cabbages were used for the test crop confirmed the 1939 evidence obtained from tomatoes.

The above results demonstrated that environmental agencies markedly influence the synthesis of vitamin C in tomatoes and cabbages, and that geographical situation is not a contributing factor except insofar as environmental conditions are consistently characteristic of that situation.

An analysis of available weather data provided a certain basis for the assumption that sunlight, rainfall, and probably temperature may all be causal agents in the variations in ascorbic acid.

Paralleling maturation of the tissue, a definite rise in ascorbic acid concentration in the tomato and a decline in the cabbage was observed. These phenomena were related to geographical situation to the extent that maturity rate was hastened or delayed by the climatic conditions prevailing throughout the growing season in any one region.

Although variations effected by environment may be of greater magnitude than varietal differences, this does not lessen the importance of the varietal values. It is obvious that if a variety of low ascorbic acid content is subjected to adverse environmental influences, the tomato may well be rendered useless as a source of vitamin C. On the other hand, a high vitamin variety subjected to the same unfavorable conditions could still contribute materially to vitamin C requirements.

A New Form of Low-Temperature Injury in Potatoes[9]

A new form of low temperature injury, for which the name mahogany browning is proposed, is caused by long exposure to medium low temperature. Chippewas and Katahdins stored at 32° F. through the winter exhibited the reddish-brown discoloration by March. No injury was shown by the same varieties stored

[9] This is an abstract of a paper by M. T. Hilborn and Reiner Bonde having the same title and published in Amer. Pot. Jour. 19: 24–29. 1942.

at 38° F. or by Green Mountains stored at 32° F. Leafroll aggravated the injury in Chippewas. Exposure to lower temperatures for short periods produced the usual freezing injury in all varieties. This injury occasionally exhibited a fluorescence, and this fluorescence was more bluish than the greenish fluorescence of internal mahogany browning. Leafroll accentuated the greenish fluorescence so that it was indistinguishable from the fluorescence of tubers infected by bacterial ring rot. Internal mahogany browning may reduce the stand and yield rate of a field planted with seed showing the injury.

METEOROLOGICAL OBSERVATIONS

The Station is indebted to the Department of Physics of the University for the meteorological summary for Orono for 1941 which appears on the following page.

The instruments used are located on the University campus at Lat. 44° 54′ 2″ N., Long. 68° 40′ 5″ W., Elevation 135 feet. They are the same as those used in preceding years and include: maximum and minimum thermometers, rain gauge, self-recording anemometer, vane, and barometers. The observations at Orono now form an almost unbroken record of seventy-three years.

METEOROLOGICAL SUMMARY FOR 1941
U. of M. Orono, Maine

1941	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	40	46	57	80	91	97	98	92	92	75	67	60	—	—
Lowest temperature	− 8	− 1	−10	23	28	41	48	41	28	18	8	− 9	—	—
Mean temperature	15.82	25.46	27.29	47.33	54.97	64.76	70.05	64.43	58.54	45.69	37.66	25.73	44.81	—
Mean temperature in 73 years	16.11	19.32	30.02	40.89	51.28	61.48	69.27	65.99	59.59	48.99	37.44	23.05	43.62	—
Total precipitation in inches	1.84	1.30	4.03	.78	1.62	1.18	1.56	1.42	.98	2.18	1.08	1.89	—	19.86
Mean total precipitation in 73 years	3.85	3.95	3.48	2.79	3.20	3.43	3.32	3.11	3.50	3.98	3.44	3.45	—	41.50
Number of days with .01 inch precipitation or more	11	5	10	7	8	8	8	8	7	11	5	6	—	94
Snowfall in inches	11	2	25	—	—	—	—	—	—	—	—	6.75		44.75
Mean snowfall in 73 years	20.49	20.39	13.78	5.23	—	—	—	—	—	.66	5.88	14.63		81.06
Number of clear days	16	11	12	17	6	11	17	11	17	11	13	8	—	150
Number of partly cloudy days	2	7	6	7	11	11	5	15	9	14	11	17		115
Number of cloudy days	13	10	13	6	14	8	9	5	4	9	6	6	—	103
Average wind velocity in miles per hour	4.71	4.68	5.02	4.41	4.16	4.07	4.21	4.25	4.26	4.37	4.39	4.64	4.47	—

METEOROLOGICAL SUMMARY
U. of M. Orono, Maine
January–June, 1942

1942	January	February	March	April	May	June
Highest temperature	52	54	64	86	84	95
Lowest temperature	–20	–11	16	23	32	35
Mean temperature	16.61	20.14	35.83	43.84	55.93	65.87
Mean temperature in 74 years	16.12	19.33	30.09	40.93	51.34	61.54
Total precipitation in inches	3.27	3.27	3.34	3.79	2.24	4.72
Mean total precipitation in 74 years	3.84	3.94	3.48	2.81	3.19	3.45
Number of days with .01 inch precipitation or more	6	5	7	13	13	12
Snowfall in inches	12.5	22	6	10.5	—	—
Mean snowfall in 74 years	20.38	20.41	13.67	5.30	—	—
Number of clear days	11	15	9	4	5	7
Number of partly cloudy days	15	9	16	10	11	15
Number of cloudy days	5	4	6	16	14	8
Average wind velocity in miles per hour	4.59	4.80	4.89	4.54	4.80	4.40

METEOROLOGICAL SUMMARY
Aroostook Farm, Presque Isle, Maine
January–June, 1942

1942	January	February	March	April	May	June
Highest temperature	47	37	44	80	81	90
Lowest temperature	–23	–19	9	15	30	31
Mean temperature	12.0	14.1	30.4	39.9	56.1	63.6
Mean temperature in 16 years	12.0	13.1	24.1	37.7	51.1	60.4
Total precipitation in inches	1.45	2.42	3.14	1.06	1.47	3.17
Mean total precipitation in 16 years	2.14[1]	1.42[1]	2.35	2.34	2.95	3.80
Number of days with .01 inch precipitation or more	5	11	11	8	8	8
Snowfall in inches	6.5	19.0	9.5	2.0	—	—
Mean snowfall in 16 years	15.41	12.85[1]	10.06[2]	3.55[2]	.01	—
Number of clear days	11	9	6	10	7	6
Number of partly cloudy days	3	2	3	7	9	11
Number of cloudy days	17	17	22	13	15	13
Average wind velocity in miles per hour	—	—	—	—	—	—

[1] Fifteen year average.
[2] Fourteen year average.

METEOROLOGICAL SUMMARY FOR 1941
Aroostook Farm, Presque Isle, Maine

1941	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	28	40	45	70	81	90	91	80	84	68	61	50	—	—
Lowest temperature	–25	–15	– 5	15	22	35	44	36	29	17	3	–11	—	—
Mean temperature	9.5	19.2	23.0	39.9	51.0	60.7	66.7	60.7	55.7	43.0	34.1	21.4	40.4	
Mean temperature in 15 years	12.0	13.0	23.7	37.5	50.7	60.2	65.7	63.4	54.9	44.1	30.7	17.3	39.4	
Total precipitation in inches	3.17	1.34	1.72	1.22	2.65	3.72	3.30	4.53	2.48	3.85	2.74	2.23	—	32.95
Mean total precipitation in 15 years	2.19[1]	1.35[1]	2.30	2.42	3.05	3.84	4.18	3.29	3.63	3.57	2.45	2.20[2]	—	34.47
Number of days with .01 inch precipitation or more	8	6	7	9	10	13	8	14	10	16	9	6	—	116
Snowfall in inches	21.0	7.0	9.0	—	—	—	—	—	—	2.0	4.0	13.0	—	56.0
Mean snowfall in 15 years	16.01	12.41[2]	10.10[1]	3.67[1]	.01	—	—	—	—	1.48	4.84[1]	12.41[1]	—	60.93
Number of clear days	13	7	8	13	10	8	10	1	7	8	4	7	—	96
Number of partly cloudy days	6	7	7	8	9	6	12	13	6	—	—	7	—	81
Number of cloudy days	12	14	16	9	12	16	9	17	17	23	26	17	—	188
Average wind velocity in miles per hour	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1] Thirteen year average.
[2] Fourteen year average.

RAINFALL RECORDS, HIGHMOOR FARM, 1942
May to October, Inclusive

Readings taken daily at 7:00 a.m.
(Inches of precipitation during preceding 24 hours)

Day	May Rain (inches)	June Rain (inches)	July Rain (inches)	August Rain (inches)	September Rain (inches)	October Rain (inches)
1	—	—	—	.06	—	—
2	—	—	.14	Trace	—	—
3	—	.04	.61	Trace	—	—
4	.09	.05	.04	—	.15	N.R.
5	.01	.56	.02	—	.01	.05
6	Trace	.01	—	—	.05	.49
7	.03	.15	.18	—	—	.18
8	.40	.06	Trace	Trace	.01	Trace
9	Trace	Trace	—	Trace	—	—
10	—	—	.09	.63	.42	—
11	Trace	—	Trace	.01	.10	—
12	—	Trace	.10	Trace	.02	Trace
13	.05	.31	.01	Trace	.02	—
14	.01	.02	—	.23	Trace	Trace
15	Trace	1.50	—	.02	—	Trace
16	Trace	1.16	—	—	—	—
17	.05	1.74	—	—	.88	—
18	.24	.86	Trace	.26	.01	.01
19	.02	.05	.01	—	.01	.19
20	Trace	.01	Trace	—	N.R.	.01
21	.33	Trace	.01	—	.43	—
22	.12	Trace	Trace	Trace	Trace	.57
23	.06	—	—	—	Trace	.30
24	.17	.02	—	—	—	.15
25	Trace	—	—	—	.13	—
26	Trace	—	—	—	Trace	.01
27	.06	—	—	—	N.R.	.17
28	.81	—	.08	—	1.08	—
29	Trace	.05	.01	—	Trace	—
30	.01	.01	1.56	.01	—	—
31	—		.18	—		Trace

N.R. = No record. Rainfall for this day included in next succeeding record.

REPORT ON THE FINANCES OF THE STATION

The Station is a department of the University and its accounts are kept in the office of the Treasurer of the University. The books, voucher files, etc., are, however, all distinct from those of the other departments of the University. The classification of accounts is that prescribed by the auditors on the part of the Federal Government, and approved by the State Auditor. All of the accounts may be audited by the State Auditor, and the Hatch Fund, Adams Fund, Purnell Fund, and Bankhead-Jones Fund accounts are also audited by the Office of Experiment Stations acting for the Secretary of Agriculture of the United States in accordance with federal law.

The cost of maintaining the laboratories for the inspection analyses is borne by analysis fees and by the State Department of Agriculture. The income from sales at the experimental farms and the poultry plant is used for the expense of investigations.

At Aroostook Farm there are, in connection with the cooperative work with the Federal Department of Agriculture, certain expenditures for the Department made from sales of crops from Department investigations. These expenditures are carried as distinct and separate accounts, always with credit balances on the Station ledger.